

III. ANALYSIS

8. Modelling and Analysis of Space and Time

Prof. Dr. Martin Langner

Schreibman / Siemens / Unsworth (2016) Kap. 14;
Jannidis / Kohle / Rehbein (2017) Kap. 21





THE CONCEPT „CULTURAL HERITAGE“

Everything that is meaningful
for the human kind, cultural
and natural

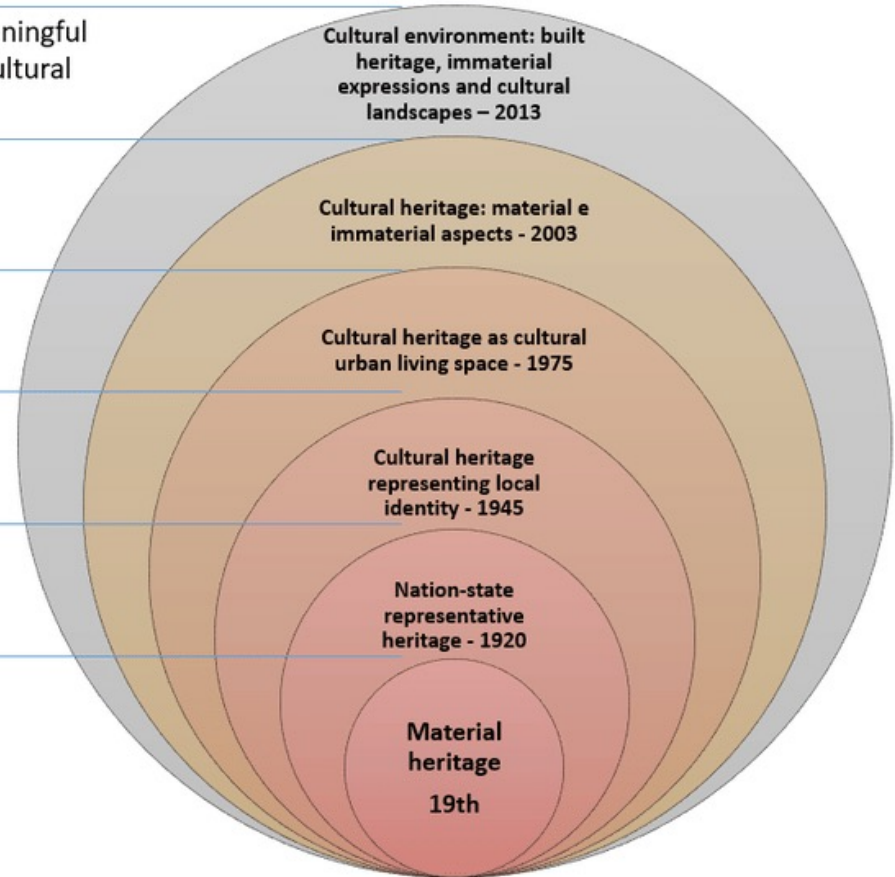
All material and
immaterial
traditional assets

Built and natural
heritage, Historical
sites

Built heritage
Expressions

Ensembles
Monuments

Buildings
Material assets



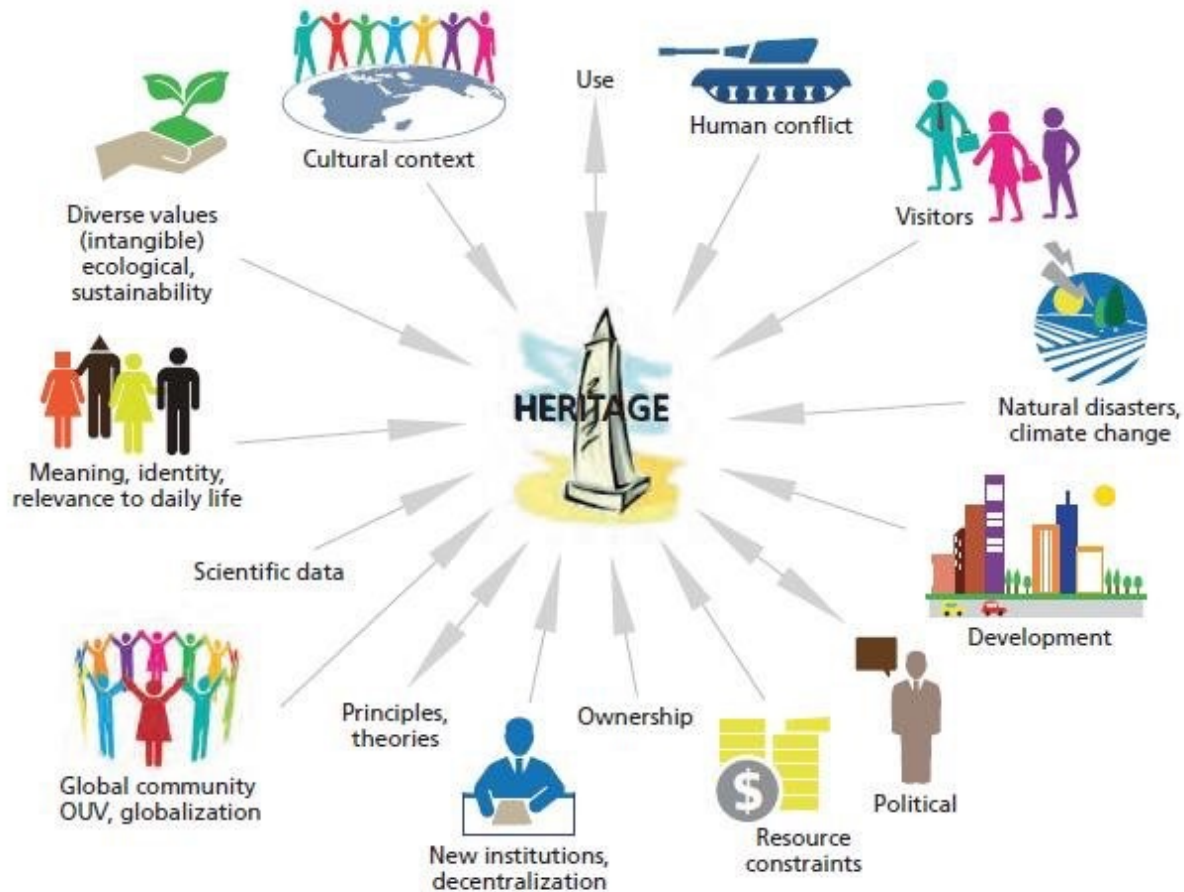
UNESCO, ICCROM, ICOMOS, IUCN, Managing
cultural world heritage, Paris 2013, 15



RELEVANT INFLUENCES ON CULTURAL HERITAGE

UNESCO, ICCROM, ICOMOS, IUCN, Managing cultural world heritage, Paris 2013, 15

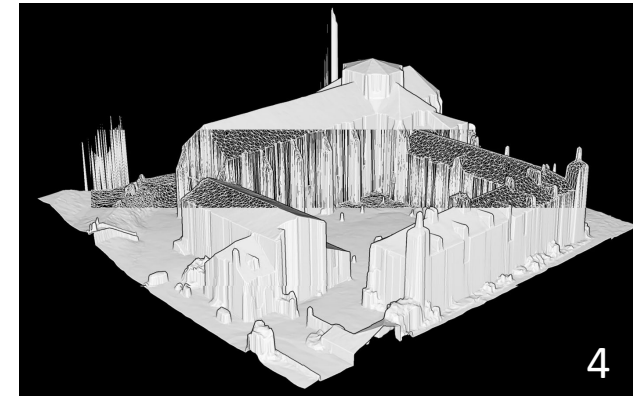
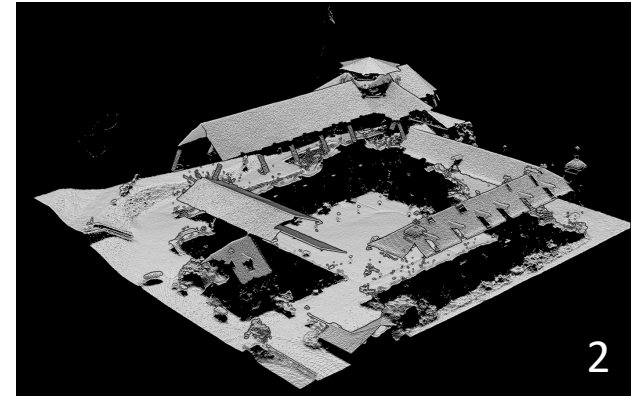
Greater complexity Greater need for suitable management approaches





Data representation of buildings in 3D models

1. photogrammetrically acquired point cloud
2. LiDAR simulated point cloud
3. multi-view (RGB raster images)
4. mesh





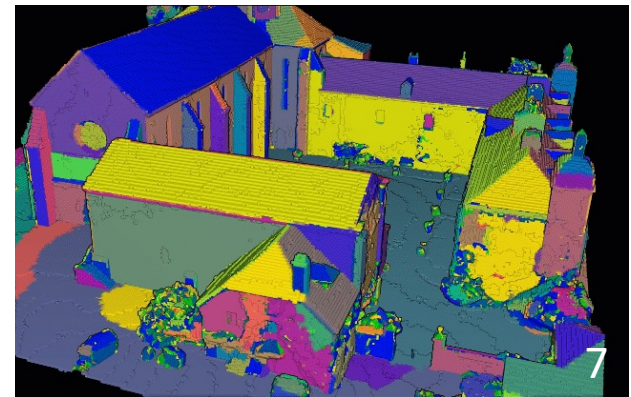
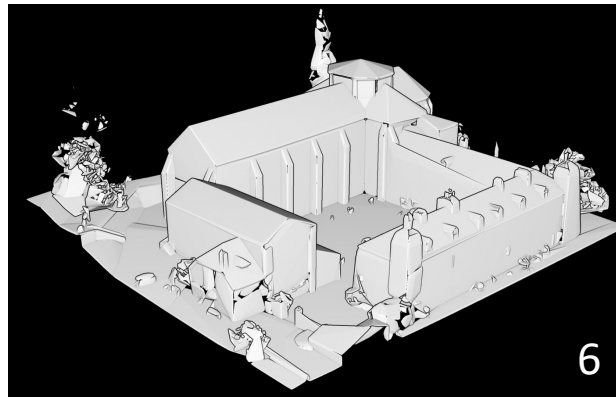
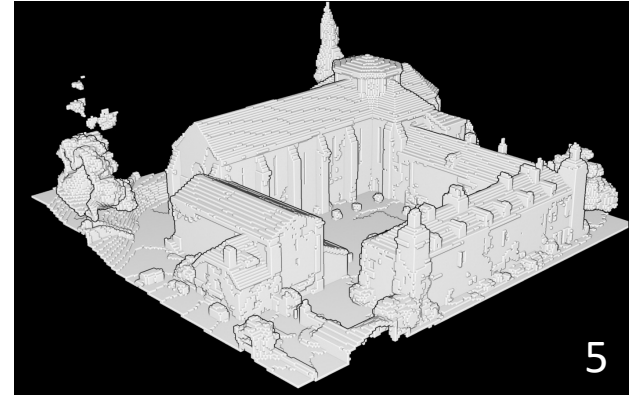
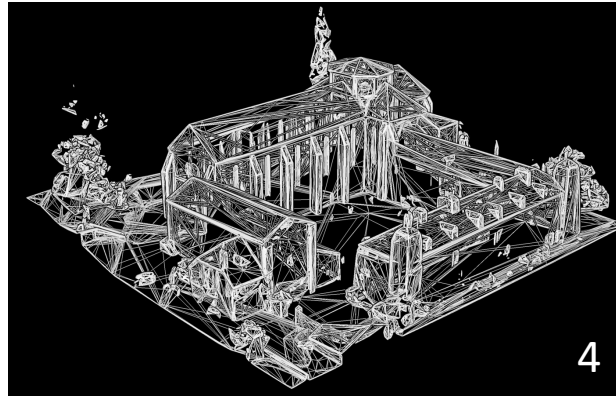
Data representations of buildings in 3D models

4. surface model (B-reps, mesh)

5. voxel model

6. parametric model (CAD)

7. automatic segmentation





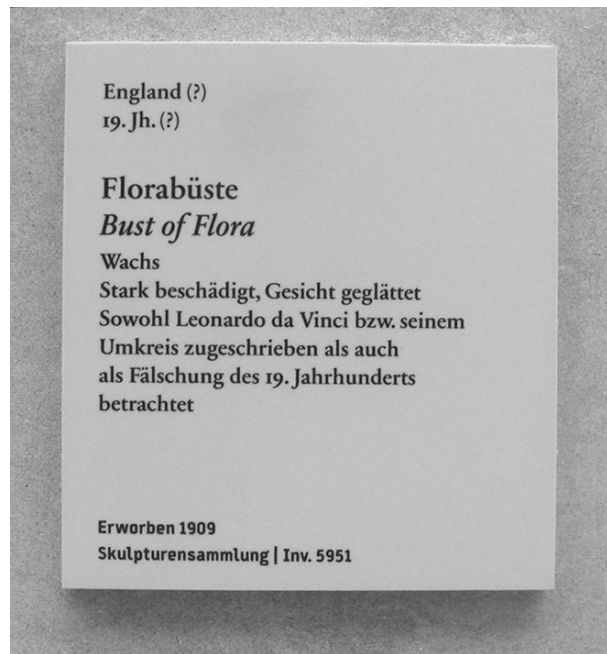
Dating is very important for the construction of historical models, as historiography is based on the integrity of datable sources.

Precise (absolute) dates are rather rare until modern times.

Dating is therefore mostly a process of estimation.

In general, there are four sources for dating:

- ancient literature and inscriptions
- archaeophysical or archaeochemical data
- stylistic series
- stratigraphic relationships



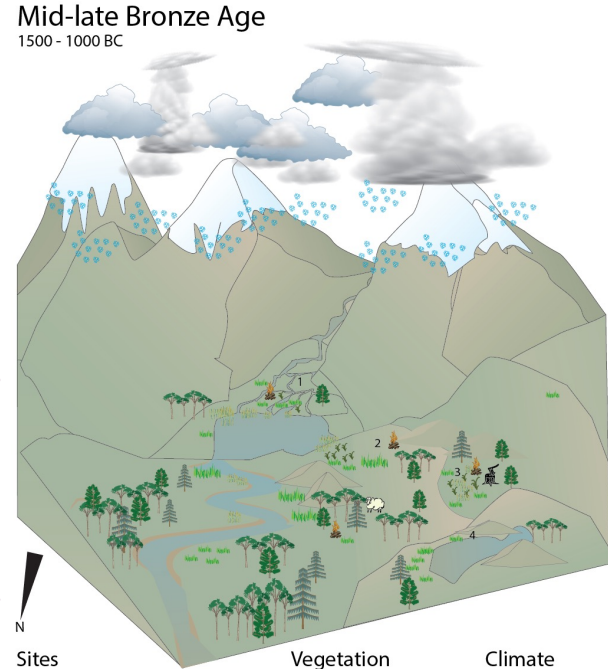


BEGINNINGS OF DIGITAL ARCHAEOLOGY

- Quantifying Archaeology
- New Archaeology (Processual Archaeology)
- Development of Geographic Information Systems (GIS)
- Environmental Archaeology

Lewis R. Binford, "Archaeology as anthropology," in: M. Leone (ed.), *Contemporary Archaeology* (Carbondale 1962), 93–101; David Clarke, "Archaeology: the loss of innocence," *Antiquity* 47 (1973), 6–18; Manfred K.H. Eggert, *Prähistorische Archäologie. Konzepte und Methoden* (Tübingen / Basel 2001); Matthew Johnson, *Archaeological Theory. An Introduction*² (Oxford 2010)

<https://intarch.ac.uk/journal/issue53/afterword.html>



Sites	Vegetation	Climate
1. LZS1	Picea	Cold/wet
2. LZSB	Pinus	Warm/damp
3. LZH1	Abies	Warm/dry
4. Lauzanier Sud - Archaeological Structures dating to the Neolithic, Bronze Age, Gallo-Roman and Modern periods.	Boggy areas (known and potential)	
	Grass	
	Damp places (representing <i>Selaginella selaginoides</i>)	
Activities		
Fire (representing charcoal peaks)		
Shelters (representing archaeological evidence)		
Pastoral activity (based upon archaeology and pastoral indicators)		
Deforestation (representing declining arboreal pollen)		

1. DIGITAL EXCAVATION ARCHAEOLOGY

Geoprospecting
Excavation documentation
Geoarchaeology
Geoinformation systems
Geovisualisation

2. PROBLEMS WITH DATING

Date formats and
chronological systems
Dating options

3. THE DIGITAL MODELLING OF SPACE AND TIME

Timeline
Fuzziness
Seriation

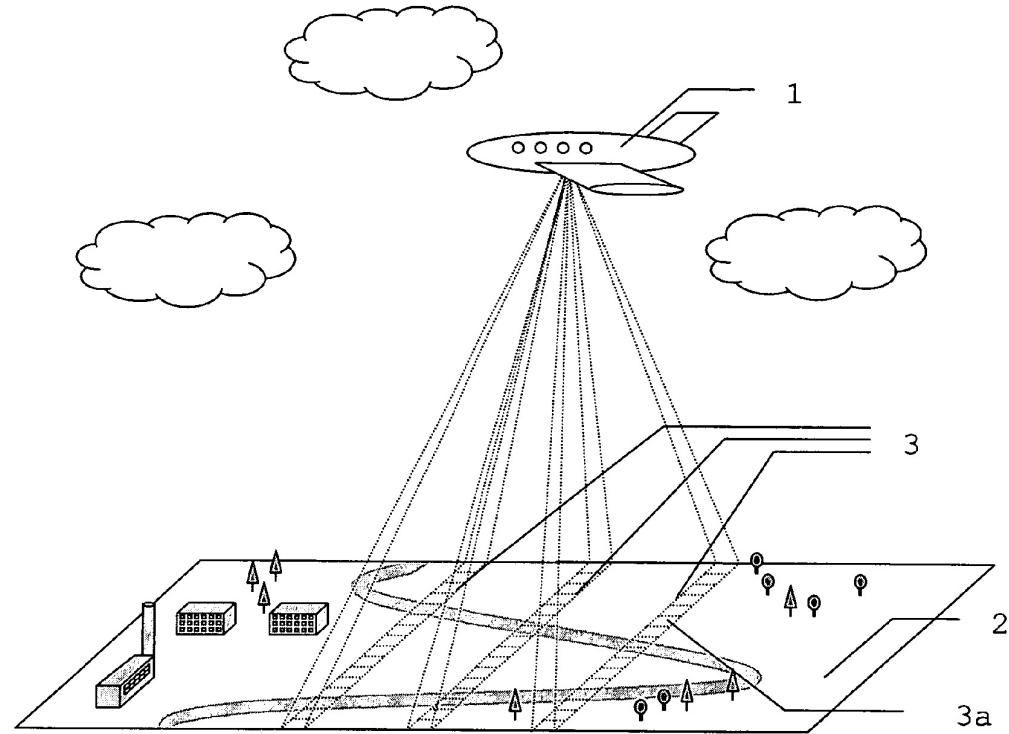


DIGITAL EXCAVATION ARCHAEOLOGY



Airborne laser scanner (LIDAR)

- Laser pulse-based scanners with medium to long range (>2 metres focal distance), also known as time-of-flight scanners
- The systems use circuitry that measures, to the picosecond, the time it takes for the light to travel from the laser to the object and back to the sensor for millions of laser pulses, and calculates the distance from each.





AERIAL PHOTOGRAPHY

Underground remains can be identified by a slight discolouration of the soil, especially after rain. With the help of aeroplanes, helicopters, balloons or drones, these are photographed and evaluated from a greater height.



Fort Arnsburg from the air

<http://www.aghessen.de/arnsburg-kastell/kastell.html>



GEOMAGNETIC

By electromagnetically measuring anomalies in the (so-called normal) earth's field, magnetised rock bodies and objects can be determined in terms of position, depth and shape.



Fort Arnsburg in the measurement image of geomagnetics
<http://www.aghessen.de/arnsburg-kastell/kastell.html>



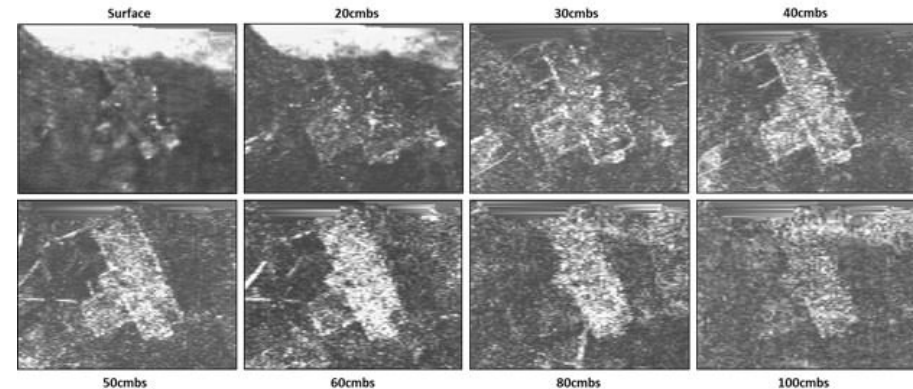
GROUND PENETRATING RADAR (GPR)

(GPR) uses electromagnetic radiation in the microwave band (UHF / VHF frequencies) of the radio spectrum.

Underground objects and stratigraphies cause reflections that are picked up by a receiver. The time of flight of the reflected signal indicates the depth.



<https://www.geophysical.com/archaeology>



Jürg Leckebusch, *Die Anwendung des Bodenradars (GPR) in der archäologischen Prospektion. 3D-Visualisierung und Interpretation* (Rahden: Leidorf 2001)

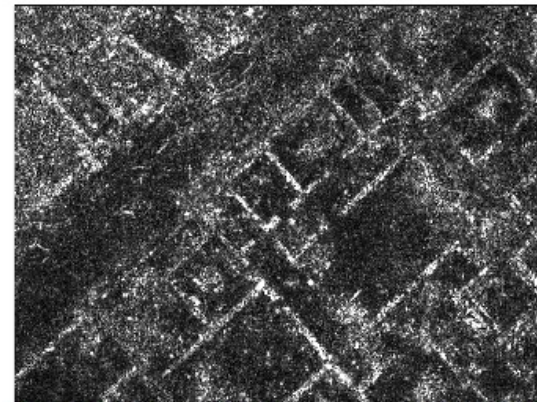


GROUND PENETRATING RADAR

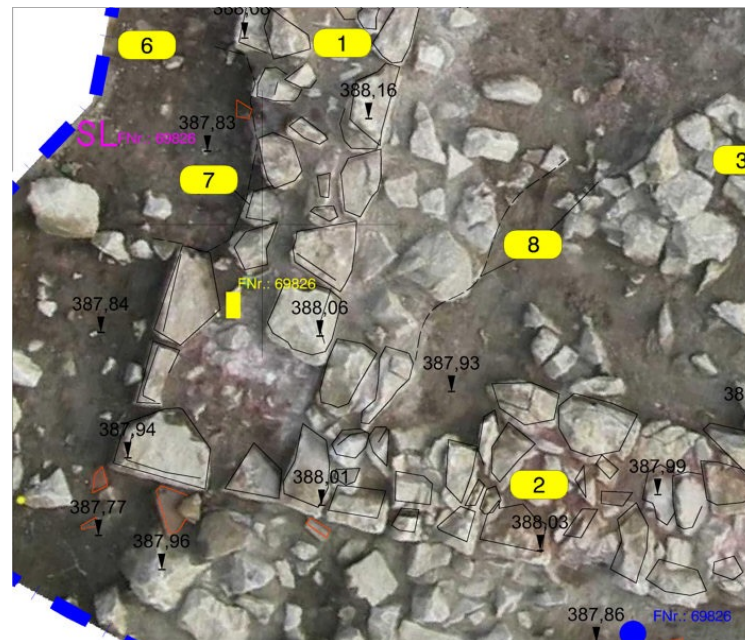
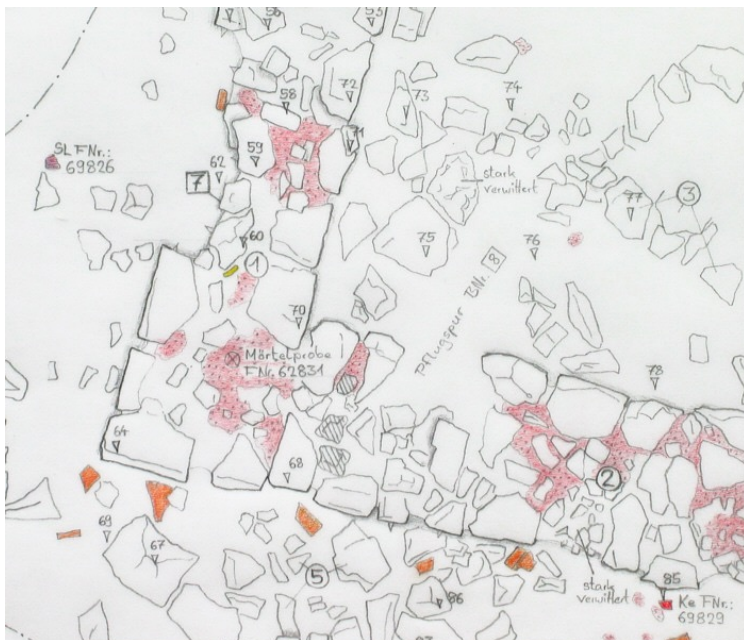
Data can be recorded as profiles, plan view maps or three-dimensional models.

The electrical conductivity of the ground, the transmitted centre frequency and the radiated power can limit the effective depth range of the GPR survey.

Ammaia (Portugal), Georadar-slice (Tiefe: c. 0.60 - 0.65 m) and Interpretation
(<https://www.ugent.be/lw/archeologie/en/research/research-projects/medrom-groundpenetratingradar.htm>)



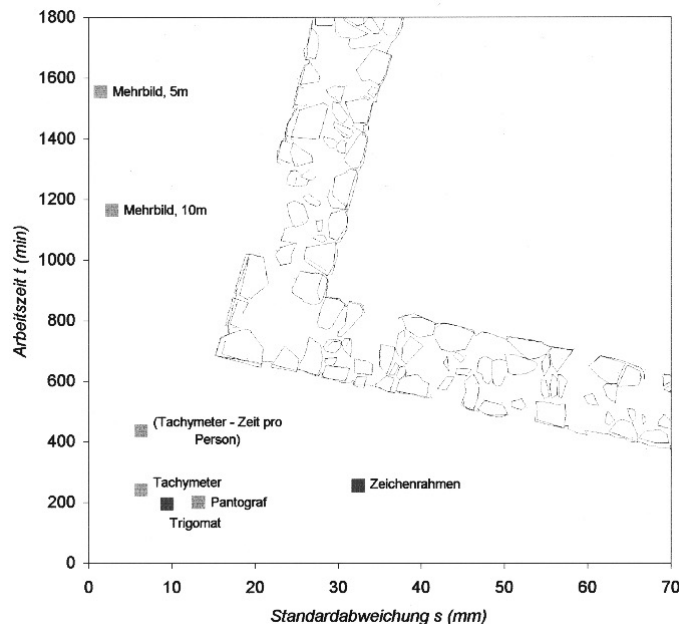
DIGITAL DOCUMENTATION OF AN EXCAVATION



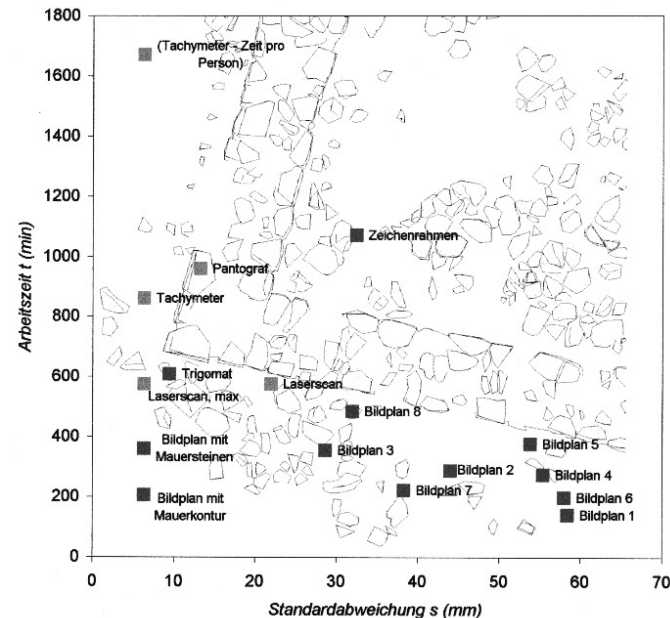
Example: Excavation of a villa rustica from Nassenfels, Eichstätt district. In the 8 x 9.5 m area lay the south-west corner of a stone outbuilding of the villa, surrounded by disordered rubble. The condition of the features corresponded to the 1st planum of the excavation.

Diagram accuracy - working time

Photogrammetric
single image
evaluation and
representation as
image plan



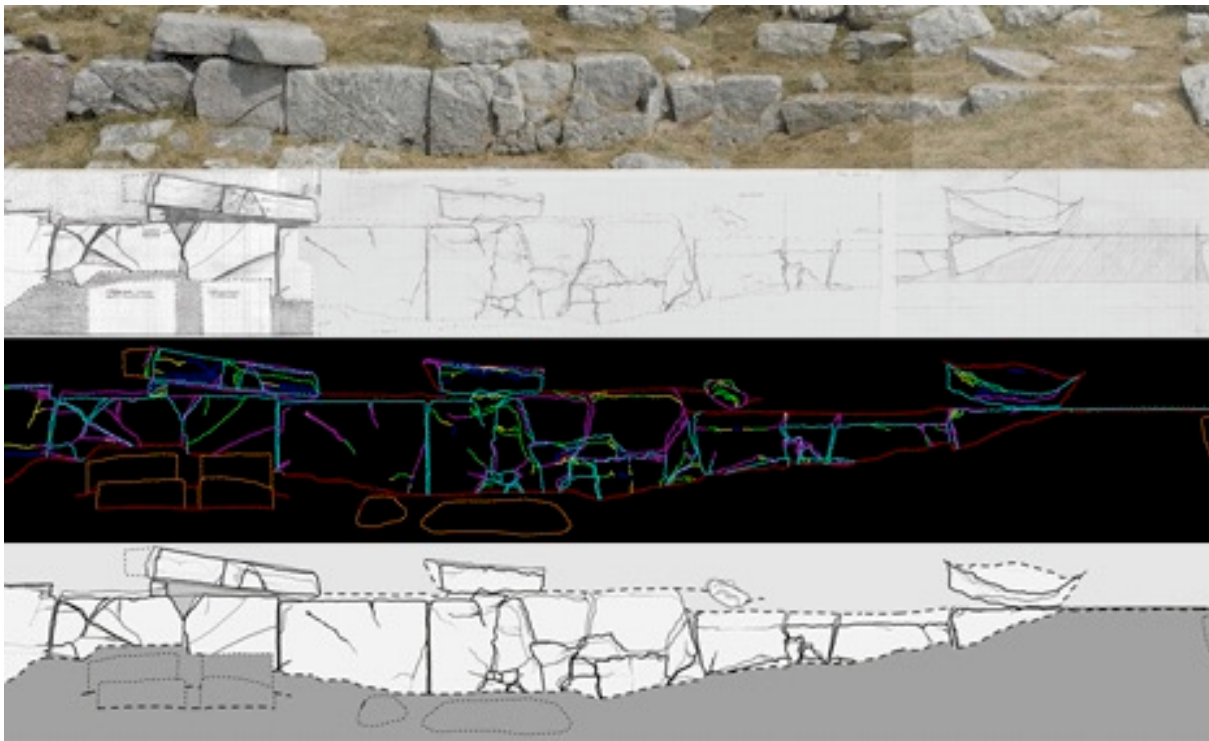
Exact acquisition of the wall without debris from the lintel



Exact acquisition of the wall with debris from the lintel



CAD (Computer Aided Design)



Stoa on Mt. Lykaion in
Arcadia:

Photostitch,

Hand drawing,

AutoCAD

Final elevation

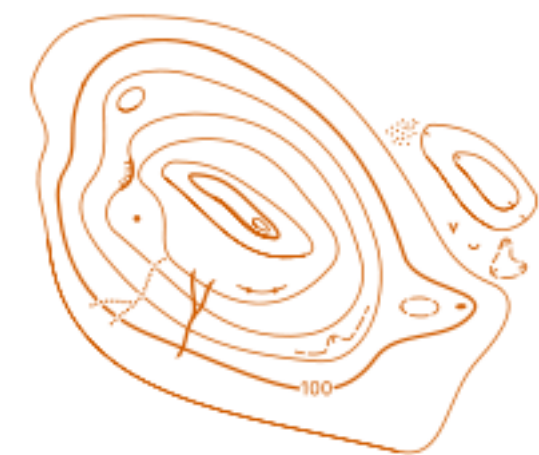
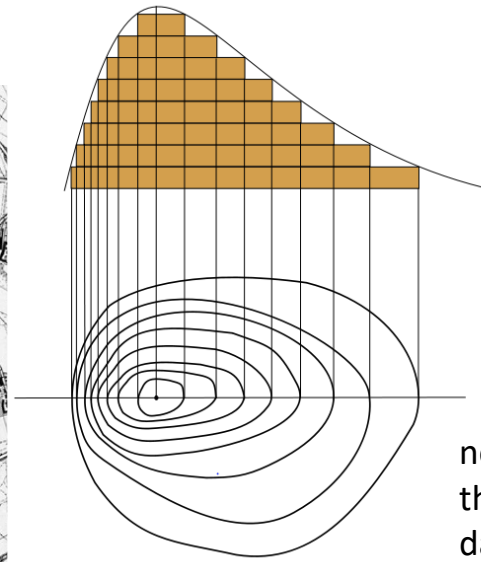
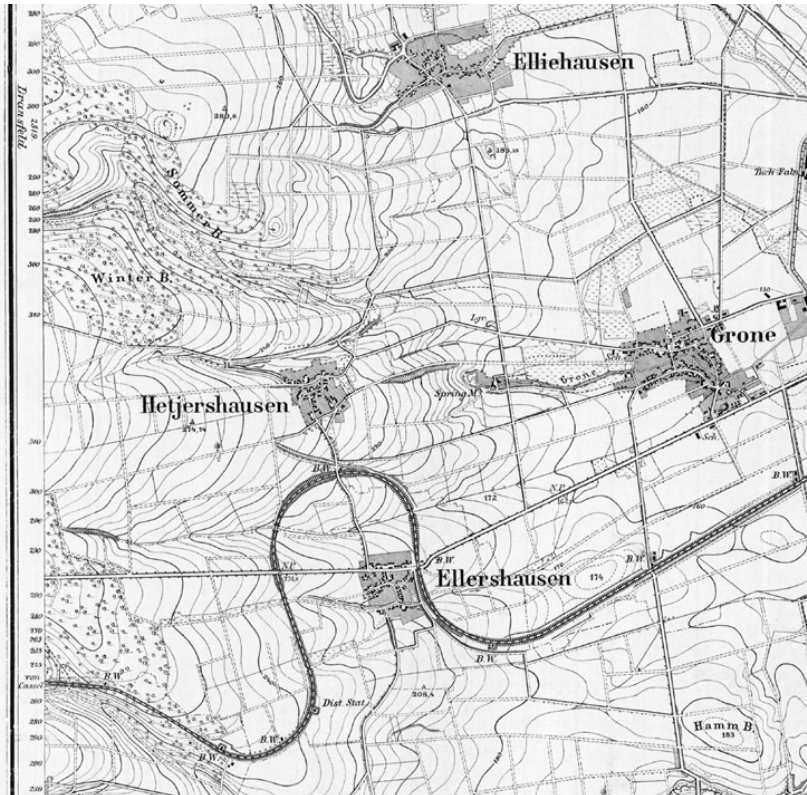
<http://lykaionexcavation.org>

GEOARCHAEOLOGY

1. acquisition, storage and analysis of geodata with geoinformation systems (GIS)
2. geovisualisation of historical spaces



CONTOUR LINE PROJECTION



normal lines = main height lines
thick lines = counting lines
dashed lines = auxiliary contour lines

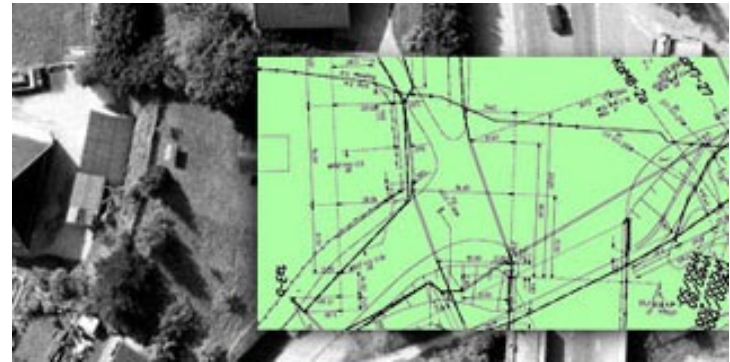
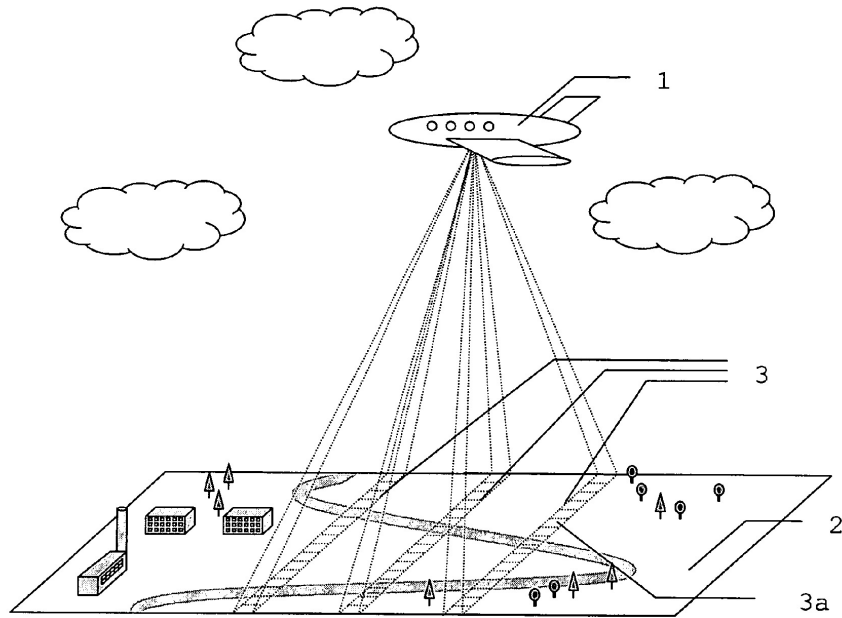


<https://dewiki.de/Lexikon/Höhenlinie>

Topographic Map of
Göttingen from 1904

www.landesarchiv-nrw.de

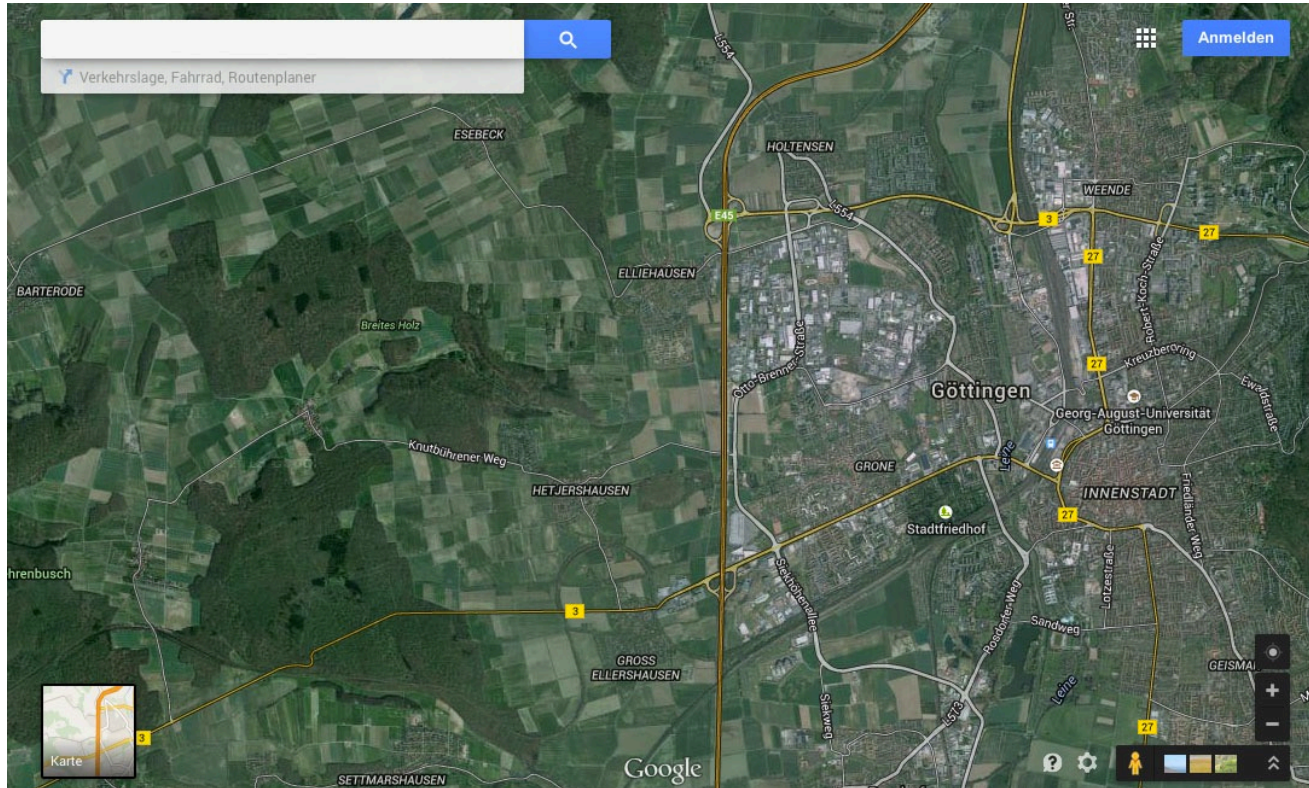
PHOTOGRAMMETRIC CREATION OF CONTOUR LINES



Geodata portals of the Federal Republic and the federal states for free downloading: <http://www.digital-geography.com/geodaten-deutschland-datenquellen-im-ueberblick/#.VLy15FrDS6Y>



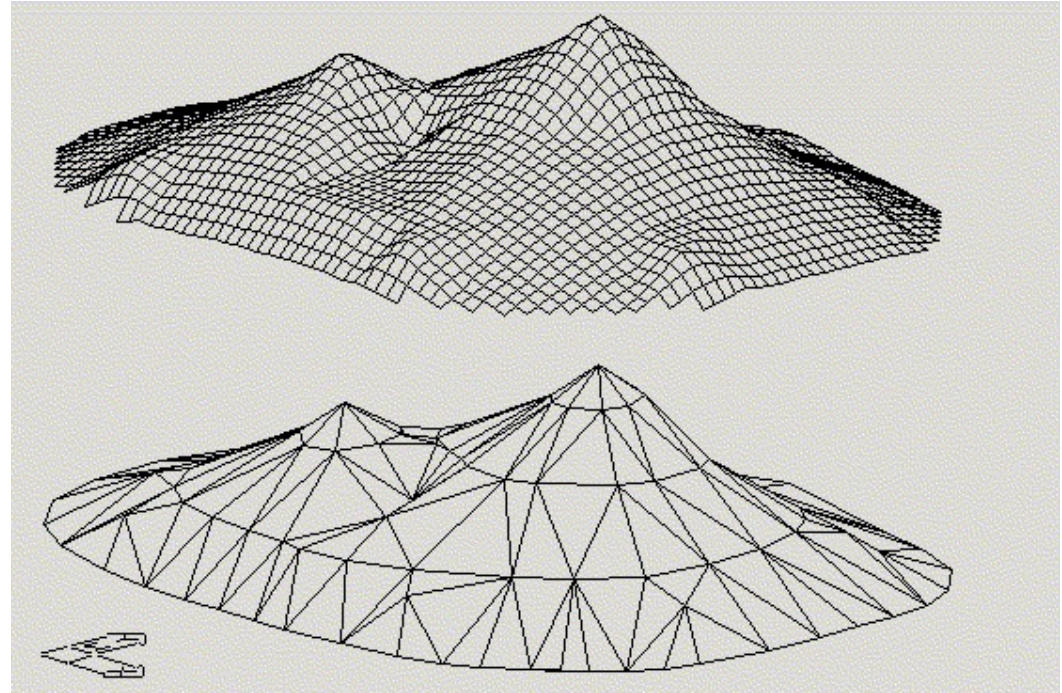
MULTIRESOLUTION ON THE FLOW



<https://www.google.de/maps/@51.5276796,9.9221504,30876m/data=!3m1!1e3>

DIGITAL TERRAIN MODEL

Exaggeration of the 3D representation through vertical stretching of the underlying coordinate system

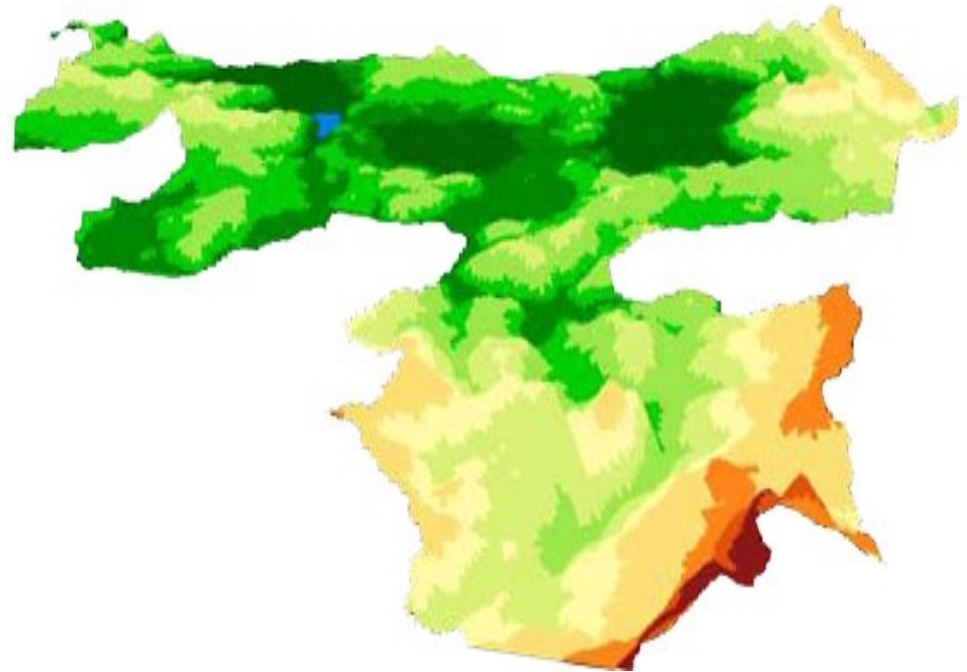


Representation of the relief as a digital terrain model based on triangulated irregular networks (TINs).

PROJECTION OF INFORMATION ONTO THE RELIEF

by colouring or texturing
the relief

Hypsometric colouring:
colour assignment as a
function of terrain height



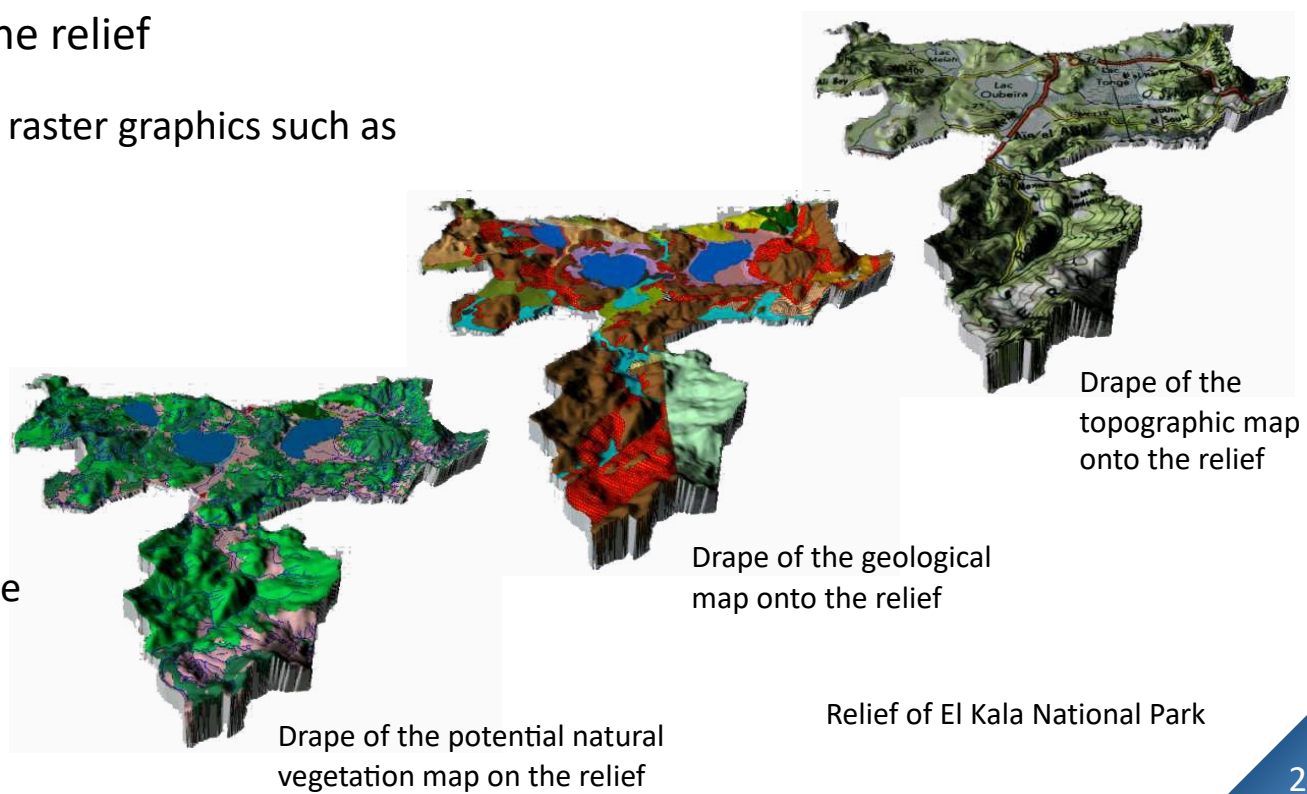
Relief of El Kala National Park in Algeria

PROJECTION OF INFORMATION ONTO THE RELIEF

by colouring or texturing the relief

"Image Drape": Texturing with raster graphics such as scanned topographic maps, aerial photographs or satellite images

- requires georeferencing of the image data
- must be projected onto the relief parallel to the xy-plane.



Drape of the topographic map onto the relief

Drape of the geological map onto the relief

Drape of the potential natural vegetation map on the relief

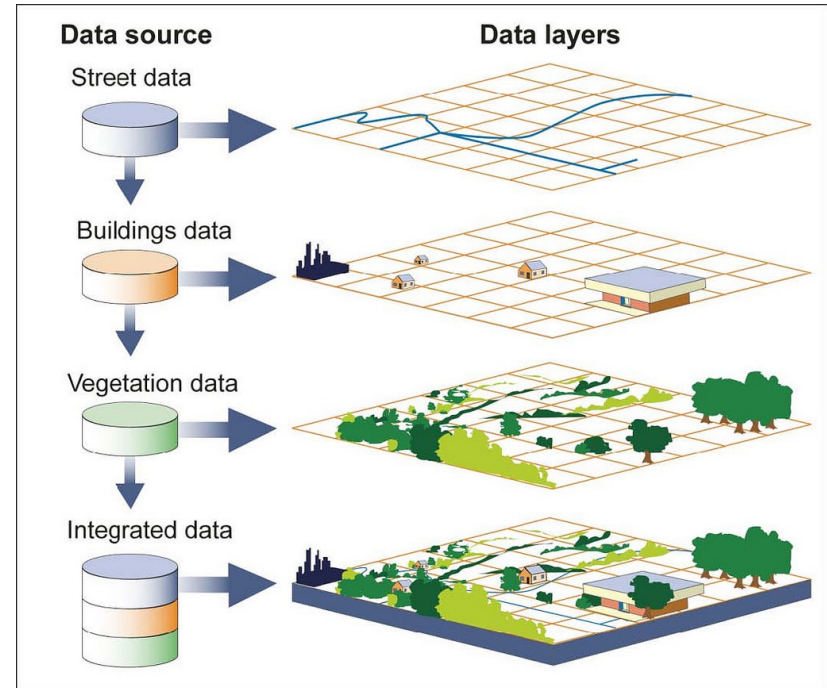
Relief of El Kala National Park

PROJECTION OF INFORMATION ONTO THE RELIEF

by colouring or texturing the relief.

Multi-texturing techniques to display thematic information:

- Combination of several texture layers
- Visual simulation of unevenness in the terrain with simplified relief representation ("bump mapping")



<https://media.nationalgeographic.org/assets/photos/000/322/32282.jpg>

POSITIONING OF VECTOR GEOOBJECTS

by colouring or texturing the relief

- Buildings, pylons, bridges, tunnels, dams, wind turbines, plants or drill profiles
- Symbols
- linear objects such as streets, land and property boundaries or building ground plans



ROME REBORN



<http://romereborn.frischerconsulting.com>

http://www.gearthblog.com/blog/archives/2008/11/ancient_rome_in_3d_for_google_earth.html



Tools for visualising data on a map:

<http://geobrowser.de.dariah.eu>

<http://openlayers.org/>

<http://www.simile-widgets.org/timeline/>

<http://gazetteer.dainst.org>

<http://nrabinowitz.github.io/gapvis/>

[s.a. http://gapvis.hellespont.dainst.org](http://gapvis.hellespont.dainst.org)

<http://orbis.stanford.edu>

<http://neatline.org>

Deutsches Archäologisches Institut
iDAI.gazetteer

Thesaurus Extended search

Karte Satellit

Bay of Biscay

Mediterranean Sea

Fehler bei Google Maps melden

zetteer

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Gibbon's History of the Decline and Fall of the Roman empire, repr. with the omission of all passages of an irreligious or immoral tendency, Volume I
By Edward Gibbon, Thomas Bowdler
Published 1826 · View on Google Books

The Google Books version of "Gibbon's History of the Decline and Fall of the Roman empire, repr. with the omission of all passages of an irreligious or immoral tendency, Volume I", by Edward Gibbon, Thomas Bowdler, was published in 1826. It references 312 identified ancient places. The place most frequently referenced is **Roma**, followed by **Italia**, **Byzantium**, and **Cirta/Constantina**.

Go to Reading View

Karte Satellit

Google Nutzungsbedingungen

★ Book Summary Reading View Place Detail

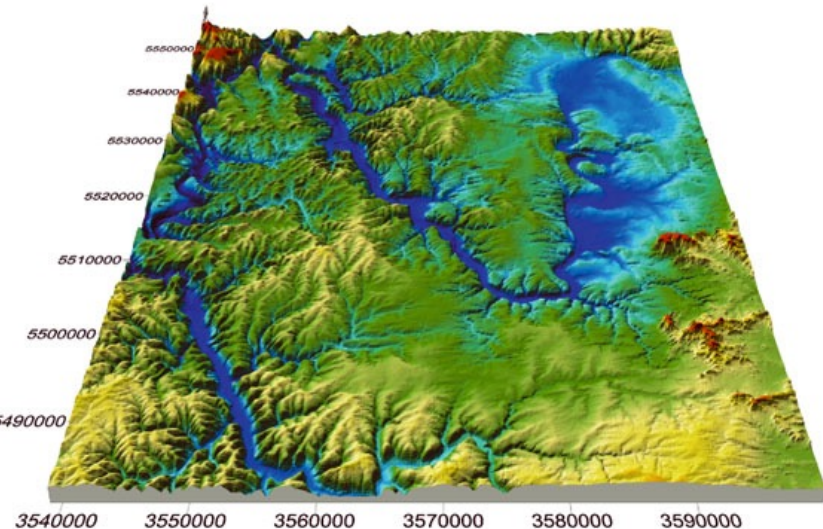
Top Places

Place	Count
Roma	141
Italia	120
Byzantium	92
Cirta/Constantina	57
Zella	50
Carthago	37
Ravenna	35
Constantinopolis	32
Dunārea	31
Hellas	28
*Asia	24
Euxine	22
Europa	21
Athenae	20
Euphrates fl.	17
Syria	16
Scitia	16
Scitia	16
Aegyptus	15
Asia	15
Indus/Tigris/Zemās fl.	15
Aegyptus	15
Africa	14
Europa	14
Herul?	13
Campania	13

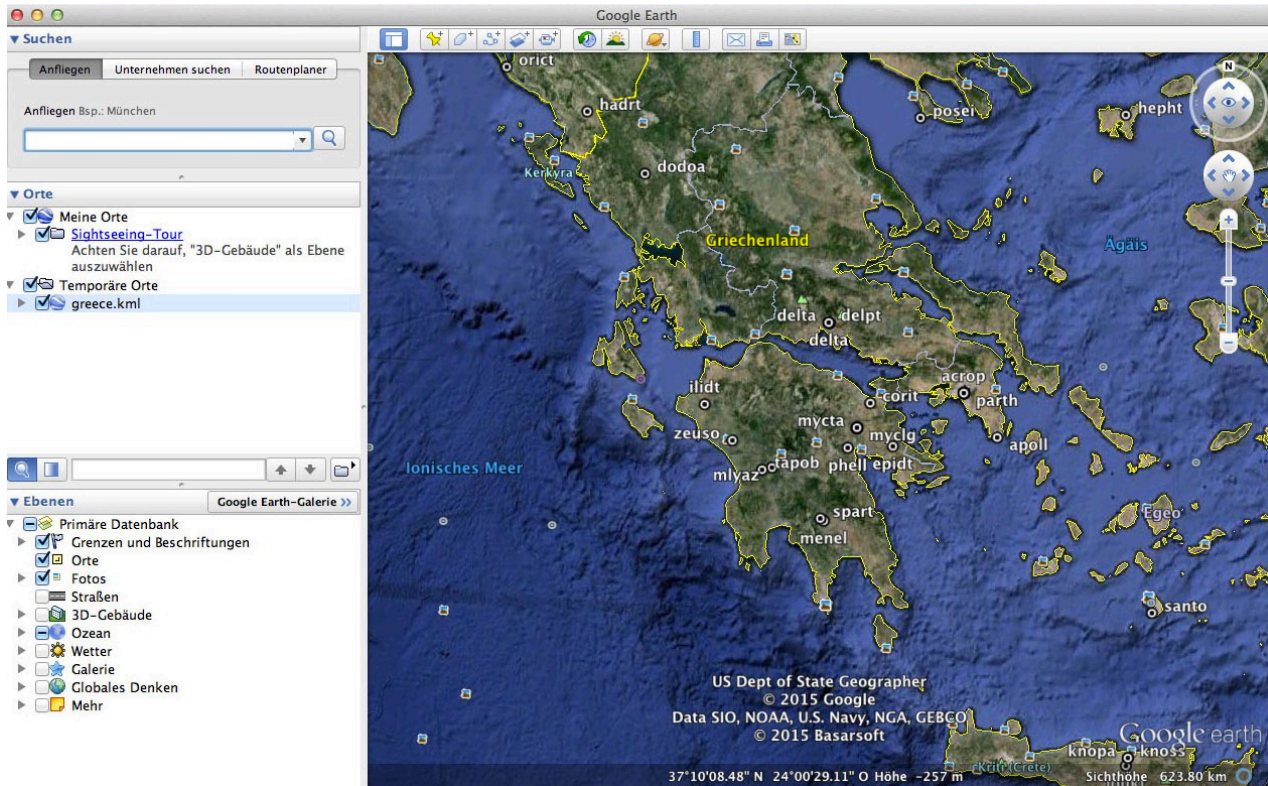
BENEFITS OF DIGITAL GEOVISUALISATION

1. Three-dimensional representation space
2. georeferenced representation
3. representation of the earth's surface ("relief", "3D topography", "terrain" or "terrain model")
4. consideration of thematic information, e.g.
 - Insertion of text
 - Cartographic conversion into colours and symbols
 - GIS connection (reading geobjects, writing back edited geometries and/or thematic attributes, calling up GIS analysis methods, etc.)
 - Varying spaces
 - varying degrees of abstraction (photorealism vs. abstract representation)

<http://www.fuerstentitze.de>

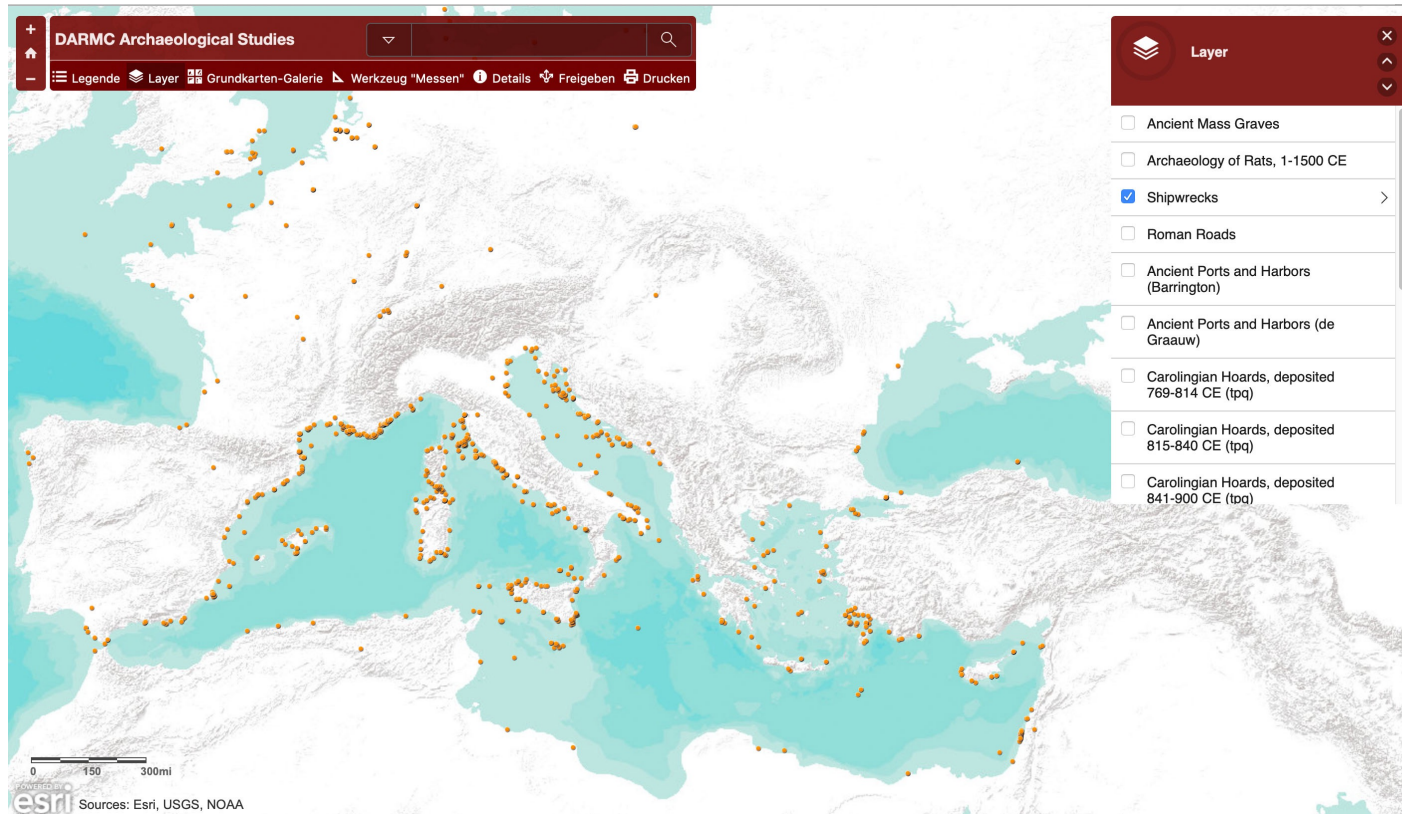


GOOGLE EARTH



<https://earth.google.de>

DIGITAL ATLAS OF ROMAN AND MEDIEVAL CIVILIZATION



<https://darmac.harvard.edu>

ARCHES. HERITAGE INVENTORY & MANAGEMENT SYSTEM



<http://archesproject.org>

What is Arches®?

Arches is an open source software platform freely available for cultural heritage organizations to independently deploy to help them manage their cultural heritage data.



GEOARCHAEOLOGY

Research in the field of settlement archaeology or landscape archaeology to reconstruct historical landscapes using scientific methods of geography (e.g. geomorphology, soil geography and settlement geography) and geology (e.g. sediment investigation and raw material analyses).

Geoscientific methods:

- Analysis of Holocene sediments (colluvia, alluvial clays, lake sediments and marine sediments).
- pollen analysis
- geophysical investigations, such as geoelectrics and georadar
- Determination of the origin of rocks (thin section, geochemical analyses).

Objectives: Acquisition and analysis

- topographical changes, such as the flooding of valleys or the silting up of lakes of utilisation potentials of the ancient population (man-environment relationship)

GEOINFORMATION SYSTEM (GIS)

- Data acquisition in the field with GPS devices
- Digitisation of paper maps and survey plans
- On-screen digitisation of satellite and aerial photographs
- Mapping of sources



extensive list of archaeological GIS, especially in Italy:
<https://www.aarome.org/research/resources/maps-gis>

GEOREFERENCING (RECTIFY MAPS)

Digitisation of paper maps and survey plans using georeferencing methods

Georeferenzierung - 189_2_ref_2.tif

Kartenkoordinaten eingeben

X- und Y-Koordinaten (DMS (dd mm ss.ss), DD (dd dd) oder projizieren Koordinaten (mmmm.mm)) die mit dem im Bild gewählten Punkt korrespondieren. Alternativ auf den Bleistift klicken und dann den korrespondierenden Punkt in der QGIS-Karte zum Füllen der Koordinate wählen.

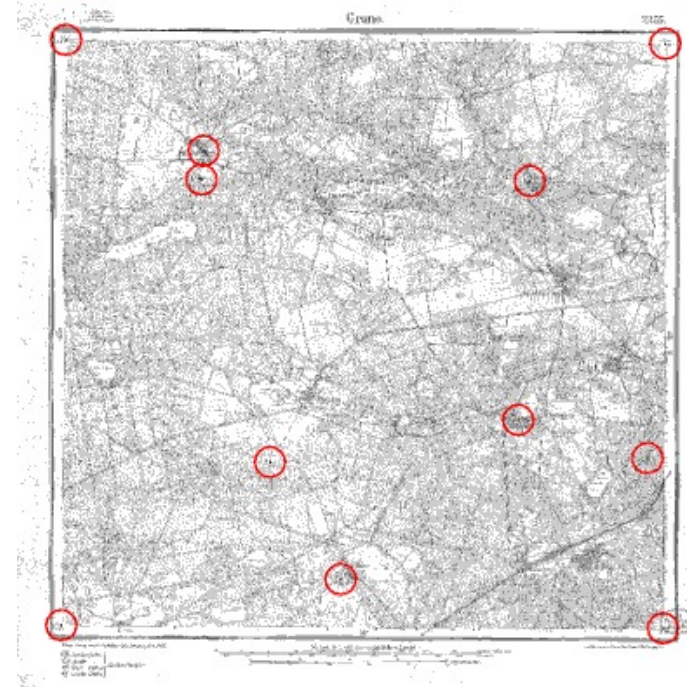
Y / Ost 418000 Y / Nord [9668000]

Hintergrundlayer fangen

Aus Kartenanzeige

Sichtbar	ID	Quelle X	Quelle Y	Ziel X	Ziel Y	dX (Pixel)	dY (Pixel)	Rest (Pixel)
<input type="checkbox"/>	1	15659,7	-6197,34	443000	9,667e+06	0	0	0
<input type="checkbox"/>	2	15803,3	-16448,5	443000	9,641e+06	0	0	0
<input type="checkbox"/>	3	6040,91	-16184,9	418000	9,642e+06	0	0	0
<input type="checkbox"/>	0	5906,03	-5907,77	418000	9,668e+06	0	0	0

Transformation: Nicht gesetzt 6488,-5541 EPSG:21037



Control points for a sheet of the Preußische Landesaufnahme of 1880 (https://www.oebvischroeder.de/leistungen/hist_preuss.html)

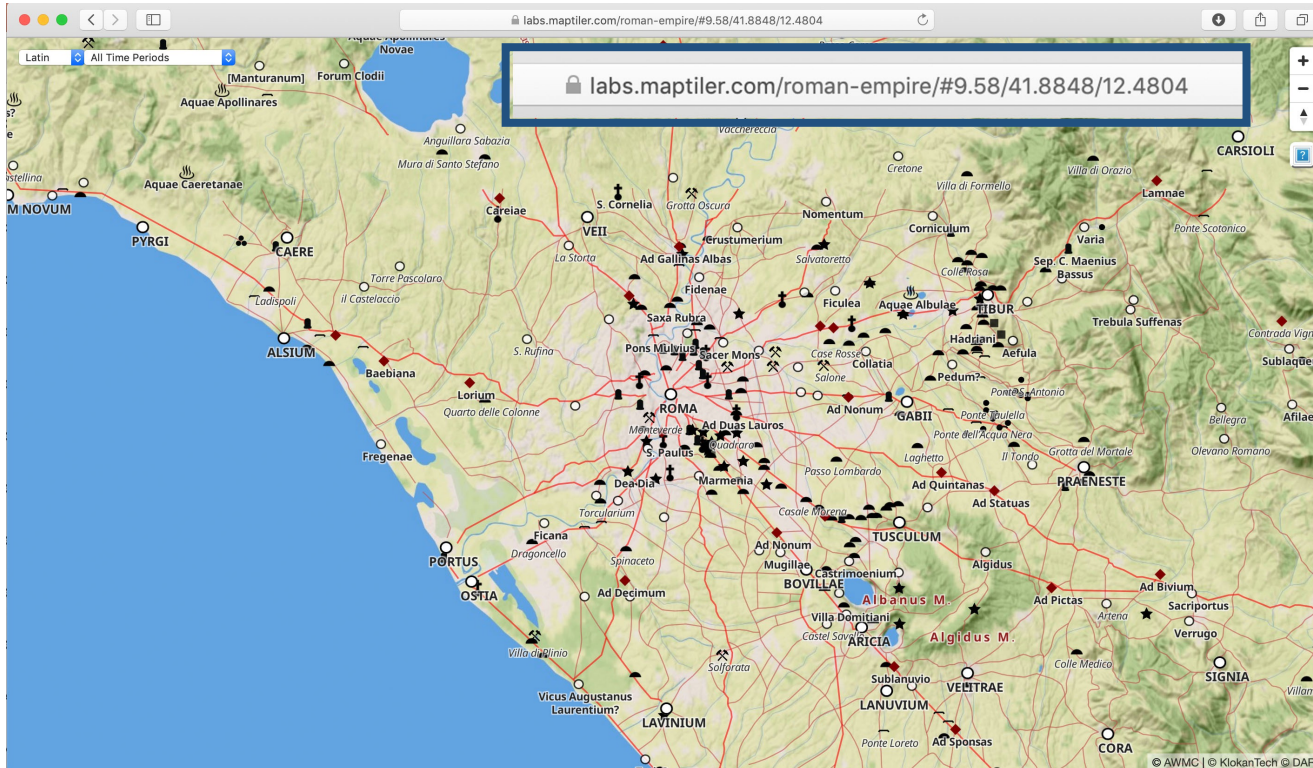


GEOREFERENCING (OpenStreetMap)

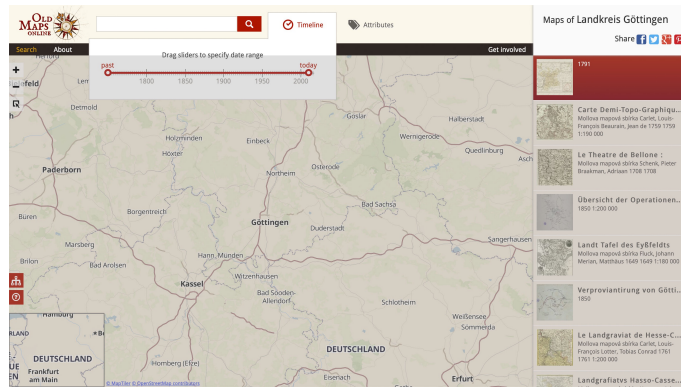
The screenshot shows the OpenStreetMap interface. The address bar contains the URL `www.openstreetmap.org/#map=13/51.5386/9.9249`. A blue box highlights this URL, and a blue arrow points to the `www.openstreetmap.org` portion. The map displays the city of Göttingen, including areas like Grone, Nordstadt, and Ostviertel. The interface includes a search bar, navigation controls, and a scale bar at the bottom left.



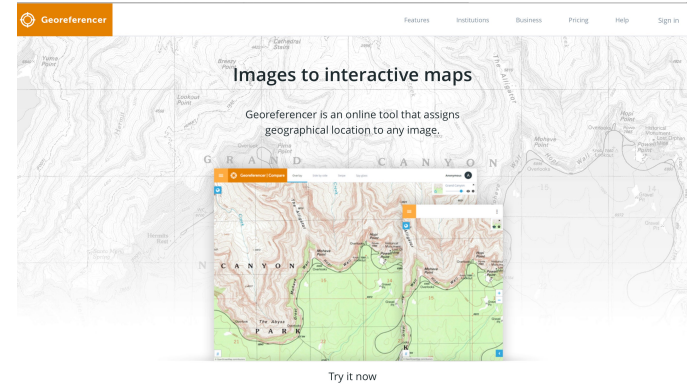
GEOREFERENCING (Digital Atlas of the Roman Empire)



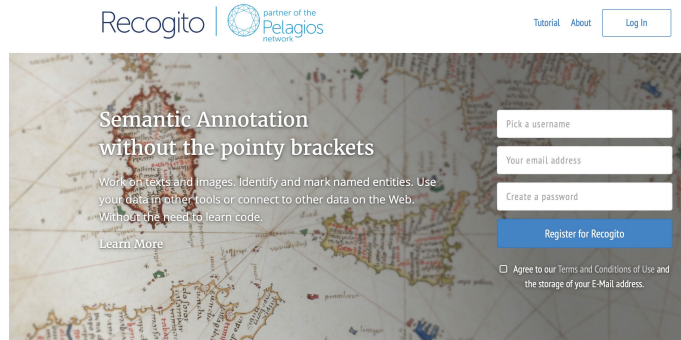
<https://dh.gu.se/dare/>



www.oldmapsonline.org

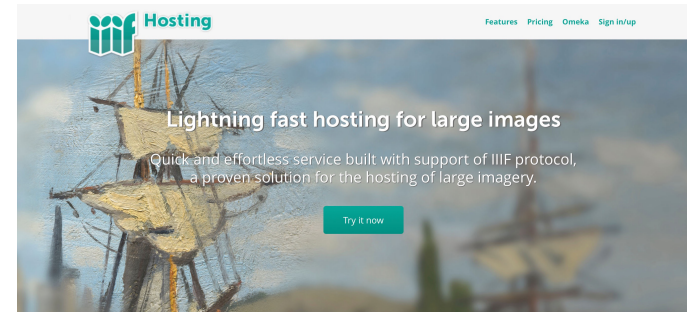


www.georeferencer.com



We are thrilled to announce that Recogito has received the title of Best Digital Humanities Tool 2018 in this year's Digital Humanities Awards. A huge Thank You to everyone who voted!

<http://recogito.pelagios.org>



Try it with your image!

www.iiifhosting.com



GEOINFORMATION SYSTEM (GIS)

A GIS is a type of database management system that links each data element to a coordinate-based representation of its location (e.g. as a point, line, polygon or pixel). It offers a wide range of possibilities as a "Historical GIS":

- Geodata technologies
- Analytical methods
- Rectification of old maps
- Display and analysis of information located anywhere on earth
- Visualisation of information in a geographic / geopolitical context
- Examination of this information at different scales. Adding data
- Finding, describing and explaining spatial patterns
- Ability to share the data
- Managing paradata (metadata in GIS)
- Access to sources, documentation of sources

ARCHAEOLOGICAL INFORMATION SYSTEM (AIS): REQUIREMENTS

- What information is digitally acquired?
- Which programmes/applications are used for the acquisition?
- Which standards are taken into account or aimed at?
- In what form is the data acquired (types, structures, standards, formats, ...)? How are geodata acquired? With CAD? With GIS? (Functionality, costs, ...)
- What role do laser scans and SfM play in 3D acquisition? Which methods, programmes and data formats are used for this?
- How are the collected data integrated into existing information systems?
- How sustainable are these data? How long can they be used? And how can long-term or permanent usability or archivability be achieved?
- What role does free and open source software play in these contexts?



ArcGIS: www.arcgis.com



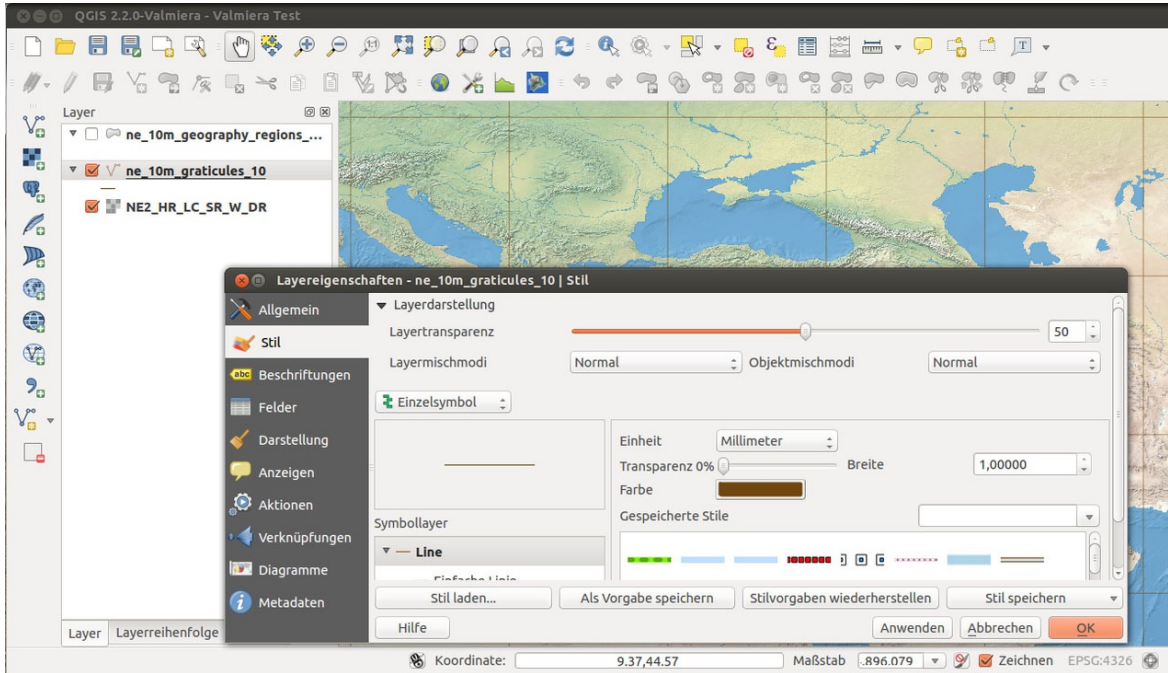
The screenshot shows the ArcGIS interface with a map of a residential area. A 'Table of Contents' window is open on the left, showing layers: 'luft.jpg' (RGB) and 'aaseeGKS.tif'. The 'aaseeGKS.tif' layer is expanded to show a legend with values 0 (black) and 0-1 (white). A 'Link Table' dialog box is open in the foreground, displaying a table of source and map coordinates.

Link	X Source	Y Source	X Map	Y Map	Residual
1	276,029114	-284,446835	3404320,147115	5759346,352710	0,47047
2	958,025616	-254,081628	3404675,345464	5759353,338776	0,27886
3	664,802780	-665,451588	3404518,758596	5759143,751569	2,37654
4	638,878745	-524,625950	3404503,446279	5759219,675144	2,61935
5	312,106119	-97,227100	3404342,028931	5759442,347161	0,37604
6	886,087655	-514,028038	3404632,962965	5759220,313157	1,02054
7	1291,270054	-510,358714	3404844,145344	5759215,847064	0,64418
8	786,557704	-252,515227	3404587,664025	5759356,209975	1,46159

Below the table, the 'Auto Adjust' checkbox is checked, and the 'Transformation' dropdown is set to '1st Order Polynomial (Affine)'. The 'Total RMS Error' is displayed as 1,43797. Buttons for 'Load...', 'Save...', 'Restore From Dataset', and 'OK' are visible at the bottom of the dialog.

ArcCatalog as data management unit
ArcMap for displaying and designing 2D maps
ArcGlobe for displaying and designing 3D globes
ArcScene for special 3D display and analysis

QGIS (früher QuantumGIS): <http://qgis.org>

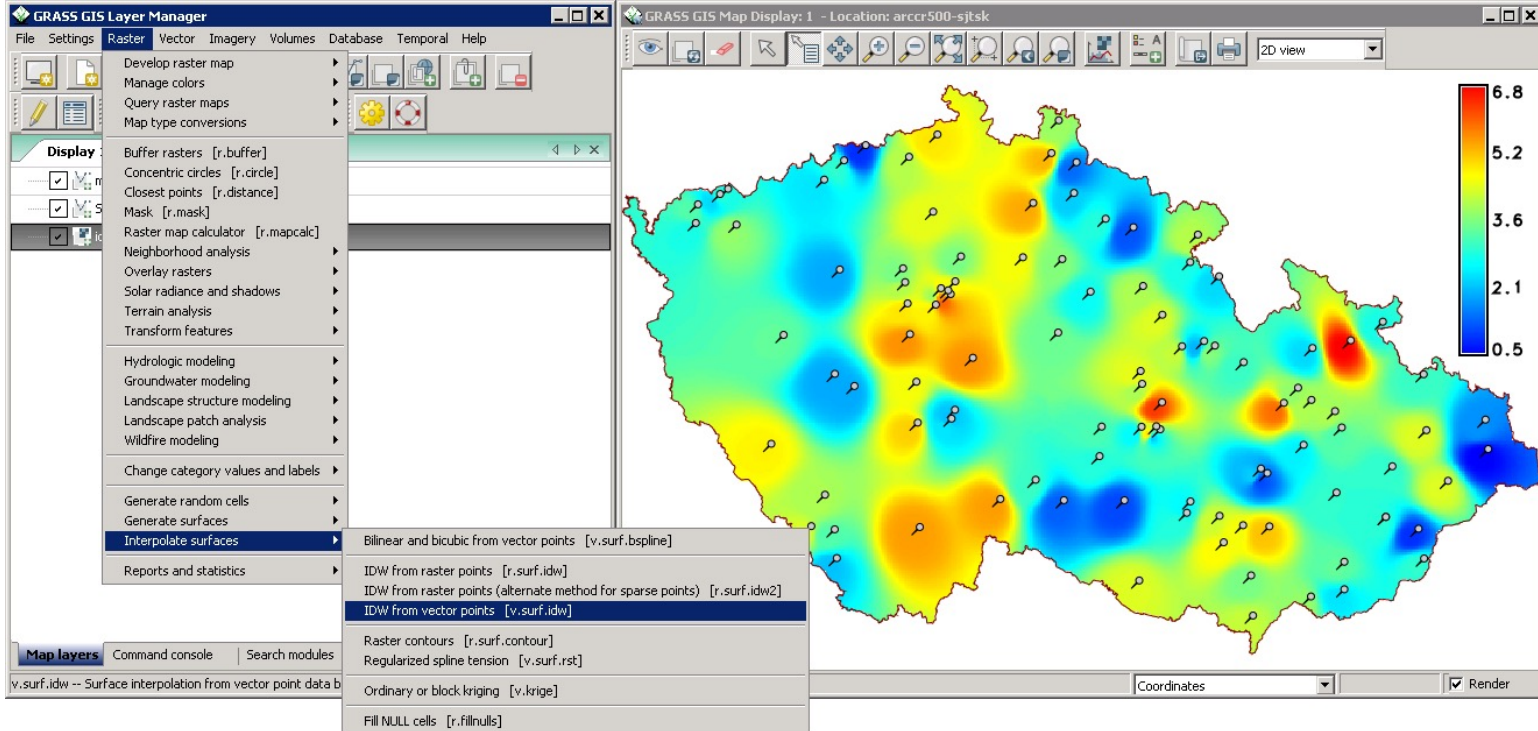


Tutorials: www.digital-geography.com/

Armin Volkmann, Archäologische Fundkartierung und Zeichnungs-Georeferenzierung mit QGIS. HeiDOK Heidelberger Dokumentenserver (2015), <http://www.ub.uni-heidelberg.de/archiv/19929>

Armin Volkmann, Tutorial Georeferencing of historical maps with QGIS. Georeferenzierung von historischen Karten mit QGIS – Ein Bilderbuch (2014), <http://archdigi.hypotheses.org/420>

GRASS GIS: <http://grass.itc.it>

The screenshot displays the GRASS GIS interface with two main windows:

- GRASS GIS Layer Manager:** Shows a menu of processing modules. The 'Interpolate surfaces' menu is open, listing options such as:
 - Bilinear and bicubic from vector points [v.surf.bspline]
 - IDW from raster points [r.surf.idw]
 - IDW from raster points (alternate method for sparse points) [r.surf.idw2]
 - IDW from vector points [v.surf.idw]** (highlighted)
 - Raster contours [r.surf.contour]
 - Regularized spline tension [v.surf.rst]
 - Ordinary or block kriging [v.krige]
 - Fill NULL cells [r.fillnulls]
- GRASS GIS Map Display: 1 - Location: arccr500-sjtsk:** Shows a 2D view of a spatial interpolation. The map uses a color scale from 0.5 (blue) to 6.8 (red). A legend on the right indicates the scale. The map contains numerous vector points and a resulting surface interpolation.

TELL EL-DABA ARCHAEOLOGICAL INFORMATION SYSTEM

Archaeological Information System (AIS) interface showing a 3D model of an archaeological site. The left sidebar contains a hierarchical tree structure for scene layers, including:

- Scene layers
 - Archaeological object type
 - building_part
 - column_foundation
 - doorsill
 - fireside
 - floor
 - foundation
 - foundation_cut
 - layer
 - oven
 - pit
 - post_hole
 - robber_pit
 - star
 - tomb
 - wall
 - wall_collapse
 - Bricks
 - Brick material
 - loamy
 - sandy
 - sandy_loamy
 - Excavation_objects
 - Excavation object type
 - Archaeotype
 - square_bench
 - test_bench
 - Finds
 - Find material
 - Fire pit
 - Pottery
 - Small find
 - Bone, human remains ?
 - Human remains
 - Stone
 - Animal bone
 - Wall plaster
 - Finds_Points
 - Section
 - Raster_data
 - Td0_F-Lj-21_gH_008.tif
 - Td0_F-Lj-21_gH_009.tif
 - Td0_F-Lj-21_gH_006.tif
 - Td0_F-Lj-21_gH007.tif
 - Td0_F-Lj-21_gH_003.tif
 - Td0_F-Lj-21_gH_002.tif
 - Td0_F-Lj-21_gH_009.tif

3D visualization of the archaeological site, showing a complex of buildings and structures. A red line indicates a specific path or feature within the site.

Table of Archaeological Objects:

OSHA GIS Identifier	Excavation object ID	Stratum ID	Td_F
L0Bed_TD_F-Lj-4	TD_F-Lj-1_Phenom_2	TD_F-83	TD_F
L0Bayer_TD_F-Lj-24	TD_F-Lj-1_Phenom_2	TD_F-83	TD_F
L0Bayer_TD_F-Lj-125	TD_F-Lj-1_Phenom_2	TD_F-82	TD_F-02
L0Bayer_TD_F-Lj-26	TD_F-Lj-1_Phenom_2	TD_F-83-1	TD_F-82
L0Bed_TD_F-Lj-42	TD_F-Lj-1_Phenom_2	TD_F-82	TD_F-83
L0Bayer_TD_F-Lj-42	TD_F-Lj-1_Phenom_2	TD_F-82	TD_F-83
L0Bed_TD_F-Lj-110	TD_F-Lj-1_Phenom_2	TD_F-82	TD_F-83
L0Bed_TD_F-Lj-8	TD_F-Lj-1_Phenom_2	TD_F-81	TD_SpezzettIT
L0Bayer_TD_F-Lj-12	TD_F-Lj-1_Phenom_2	TD_F-83-2	TD_F-83
L0Bed_TD_F-Lj-76	TD_F-Lj-1_Phenom_2	TD_F-82	TD_F-83
L0Bayer_TD_F-Lj-24	TD_F-Lj-1_Phenom_2	TD_F-82	TD_F-83
L0Bed_TD_F-Lj-50	TD_F-Lj-1_Phenom_2	TD_F-81	TD_SpezzettIT
L0Bayer_TD_F-Lj-44	TD_F-Lj-1_Phenom_2	TD_F-82	TD_F-83
L0Bayer_TD_F-Lj-30	TD_F-Lj-1_Phenom_2	TD_F-82-1	TD_F-82
L0Bayer_TD_F-Lj-29	TD_F-Lj-1_Phenom_2	TD_F-82-1	TD_F-82
L0Bayer_TD_F-Lj-53	TD_F-Lj-1_Phenom_2	TD_F-82	TD_F-83
L0Bayer_TD_F-Lj-19	TD_F-Lj-1_Phenom_2	TD_F-82	TD_F-83
L0Bed_TD_F-Lj-17	TD_F-Lj-1_Phenom_2	TD_F-81	TD_F-82
L0Bayer_TD_F-Lj-48	TD_F-Lj-1_Phenom_2	TD_F-82	TD_F
L0Bayer_TD_F-Lj-38	TD_F-Lj-1_Phenom_2	TD_F-82	TD_F-83
L0Bed_TD_F-Lj-49	TD_F-Lj-1_Phenom_2	TD_F-81	TD_SpezzettIT
L0Bayer_TD_F-Lj-180	TD_F-Lj-1_Phenom_1-2	TD_F-81-a1	TD_SpezzettIT
L0Bayer_TD_F-Lj-24	TD_F-Lj-1_Phenom_1	TD_F-80-1	TD_F-82
L0Bayer_TD_F-Lj-8	TD_F-Lj-1_Phenom_1	TD_F-83-2	TD_F-83
L0Bayer_TD_F-Lj-17	TD_F-Lj-1_Phenom_1	TD_F-81	TD_F-82
L0Bed_TD_F-Lj-145	TD_F-Lj-1_Phenom_1	TD_SpezzettIT	TD_SpezzettIT
L0Bayer_TD_F-Lj-8	TD_F-Lj-1_Phenom_1	TD_F-83-1	TD_F-82
L0Bayer_TD_F-Lj-20	TD_F-Lj-1_Phenom_1	TD_F-81	TD_F-82
L0Bayer_TD_F-Lj-18	TD_F-Lj-1_Phenom_1	TD_F-81	TD_F-82
L0Bayer_TD_F-Lj-145	TD_F-Lj-1_Phenom_1	TD_F-83-1	TD_F-82
L0Bayer_TD_F-Lj-16	TD_F-Lj-1_Phenom_1	TD_F-83-2	TD_F-83
L0Bed_TD_F-Lj-2	TD_F-Lj-1_Phenom_1	TD_F-82	TD_F-83
L0Bayer_TD_F-Lj-26	TD_F-Lj-1_Phenom_1	TD_F-81	TD_F-82
L0Bayer_TD_F-Lj-1	TD_F-Lj-1_Phenom_1	TD_F-83-2	TD_F-83
L0Bayer_TD_F-Lj-25	TD_F-Lj-1_Phenom_1	TD_F-81	TD_F-82
L0Bed_TD_F-Lj-49	TD_F-Lj-1_Phenom_1	TD_F-82	TD_F-02
L0Bayer_TD_F-Lj-3	TD_F-Lj-1_Phenom_0-1	TD_F-80	TD_F-02
L0Bayer_TD_F-Lj-15	TD_F-Lj-1_Phenom_0-1	TD_F-83-2	TD_F-83
L0Bayer_TD_F-Lj-11	TD_F-Lj-1_Phenom_0-1	TD_F-83-2	TD_F-83
L0Bayer_TD_F-Lj-2	TD_F-Lj-1_Phenom_0-1	TD_F-82	TD_F-02
L0Bayer_TD_F-Lj-4	TD_F-Lj-1_Phenom_0-1	TD_F-83-2	TD_F-83
L0Bayer_TD_F-Lj-189	TD_F-Lj-1_Phenom_0-1	TD_F-80-1	TD_F-82
L0Bayer_TD_F-Lj-1	TD_F-Lj-1_Phenom_0-1	TD_F-83-1	TD_F-82
L0Bayer_TD_F-Lj-7	TD_F-Lj-1_Phenom_0-1	TD_F-83-2	TD_F-83
L0Bayer_TD_F-Lj-5	TD_F-Lj-1_Phenom_0-1	TD_F-81	TD_F-82
L0Bed_TD_F-Lj-136	TD_F-Lj-1_Phenom_0-1	TD_F-80	TD_H
L0Bed_TD_F-Lj-134	TD_F-Lj-1_Phenom_0-1	TD_F-82	TD_H
L0Bed_TD_F-Lj-125	TD_F-Lj-1_Phenom_0-1	TD_F-82	TD_F-02
L0Bed_TD_F-Lj-124	TD_F-Lj-1_Phenom_0-1	TD_F-82	TD_F-02
L0Bed_TD_F-Lj-141	TD_F-Lj-1_Phenom_0-1	TD_F-82	TD_F-02
L0Bed_TD_F-Lj-122	TD_F-Lj-1_Phenom_0-1	TD_F-82	TD_F-02
L0Bed_TD_F-Lj-13	TD_F-Lj-1_Phenom_0-3	TD_F-81	TD_SpezzettIT
L0Bed_TD_F-Lj-137	TD_F-Lj-1_Phenom_0-3	TD_F-83	TD_F
L0Bed_TD_F-Lj-182	TD_F-Lj-1_Phenom_0-3	TD_F-81	TD_F-82
L0Bed_TD_F-Lj-119	TD_F-Lj-1_Phenom_0-3	TD_F-81	TD_03-1
L0Bed_TD_F-Lj-99	TD_F-Lj-1_Phenom_0-3	TD_F-81	TD_03-1
L0Bed_TD_F-Lj-189	TD_F-Lj-1_Phenom_0-3	TD_F-81	TD_03-1
L0Bed_TD_F-Lj-35	TD_F-Lj-1_Phenom_0-3	TD_F-82	TD_F-02
L0Bed_TD_F-Lj-117	TD_F-Lj-1_Phenom_0-3	TD_F-81	TD_SpezzettIT
L0Bed_TD_F-Lj-11	TD_F-Lj-1_Phenom_0-3	TD_F-81	TD_SpezzettIT
L0Bed_TD_F-Lj-75	TD_F-Lj-1_Phenom_0-3	TD_F-83	TD_F
L0Bed_TD_F-Lj-12	TD_F-Lj-1_Phenom_0-1	TD_SpezzettIT	TD_SpezzettIT
L0Bed_TD_F-Lj-144	TD_F-Lj-1_Phenom_0-1	TD_F-81	TD_SpezzettIT
L0Bed_TD_F-Lj-1	TD_F-Lj-1_Phenom_0-1	TD_F-81	TD_F-82

<https://4dpuzzle.orea.oeaw.ac.at/ais/>



TELL EL-DABA ARCHAEOLOGICAL INFORMATION SYSTEM

*A Puzzle in 4D GIS case study - QGIS

Projekt Bearbeiten Ansicht Layer Einstellungen Erweiterungen Vektor Raster Datenbank Web Verarbeitung Hilfe

Layer

- TD_FI_j21_Planum1
- TD_FI_j21_Planum2
- TD_FI_j21_Planum2_1
- TD_FI_j21_Planum2_2
- TD_FI_j21_Planum2-3 [284]**
 - fire pit [0]
 - pottery [22]
 - small find [0]
 - bone, human remains, human remains? [141]
 - stone [0]
 - wall plaster [0]
 - mud brick [3]
 - brick [0]
 - sand brick [70]
 - sand-mud brick [0]
 - sand brick bench [0]
 - sand brick floor [20]
 - column_foundation, foundation, staircase, fo...
 - fire_pt_layer_ash_layer_ash_sand_wal_collaps...
 - floor [0]
 - foundation_cut [1]
 - layer_wal_collapse [3]
 - layer_mud_threshold_mud [0]
 - layer_sand_wal_collapse_sand [0]
 - layer_sand_mud_wal_collapse_sand_mud [2]
 - oven [0]
 - pit [3]
 - post_hole [0]
 - robber_pit [0]
 - threshold [0]
 - tomb [2]
 - wall [9]
 - Naville pit [4]
- TD_FZ_1096
 - TD_FI_j21_Planum3
 - TD_FI_j21_Planum4
 - TD_FI_j21_Planum4-5
 - TD_FI_j21_Planum4-K2
 - TD_FI_j21_Planum4-K3
 - TD_FI_j21_Planum4-K4
 - TD_FI_j21_Planum5
 - TD_FI_j21_Planum5_1

TD_FI_j21_Planum2-3: Objekte gesamt:284, gefiltert: 284, gewählt: 1

OREA_GIS_ID	Excavation_object_ID	Archaeological_Object_ID	Archaeological_object_type	rchaeolog
1	LBifind_TD-F-Ij21_753	TD-F-Ij21_Planum2-3	LBifind_TD-F-Ij21_M3...	wall
2	LBifind_TD-F-Ij21_1112	TD-F-Ij21_Planum2-3	TD-F-Ij25	Mauer
3	LBifind_TD-F-Ij21_787	TD-F-Ij21_Planum2-3	TD-F-Ij_M32	
4	LBifind_TD-F-Ij21_1044	TD-F-Ij21_Planum2-3	TD-F-Ij25	
5	LBifind_TD-F-Ij21_1126	TD-F-Ij21_Planum2-3	TD-F-Ij25	
6	LBifind_TD-F-Ij21_1059	TD-F-Ij21_Planum2-3	TD-F-Ij25	
7	LBifind_TD-F-Ij21_1086	TD-F-Ij21_Planum2-3	TD-F-Ij25	
8	LBifind_TD-F-Ij21_1102	TD-F-Ij21_Planum2-3	TD-F-Ij25	

Alle Objekte anzeigen

<https://4dpuzzle.oeaw.ac.at/ais/>



TELL EL-DABA ARCHAEOLOGICAL INFORMATION SYSTEM

The screenshot shows the ArcMap interface with a map of Tell el-Daba. A 'Layer Properties' dialog box is open, displaying the 'Fields' tab. The dialog box shows a table with columns for Symbol, Value, Label, and Count. The table contains the following data:

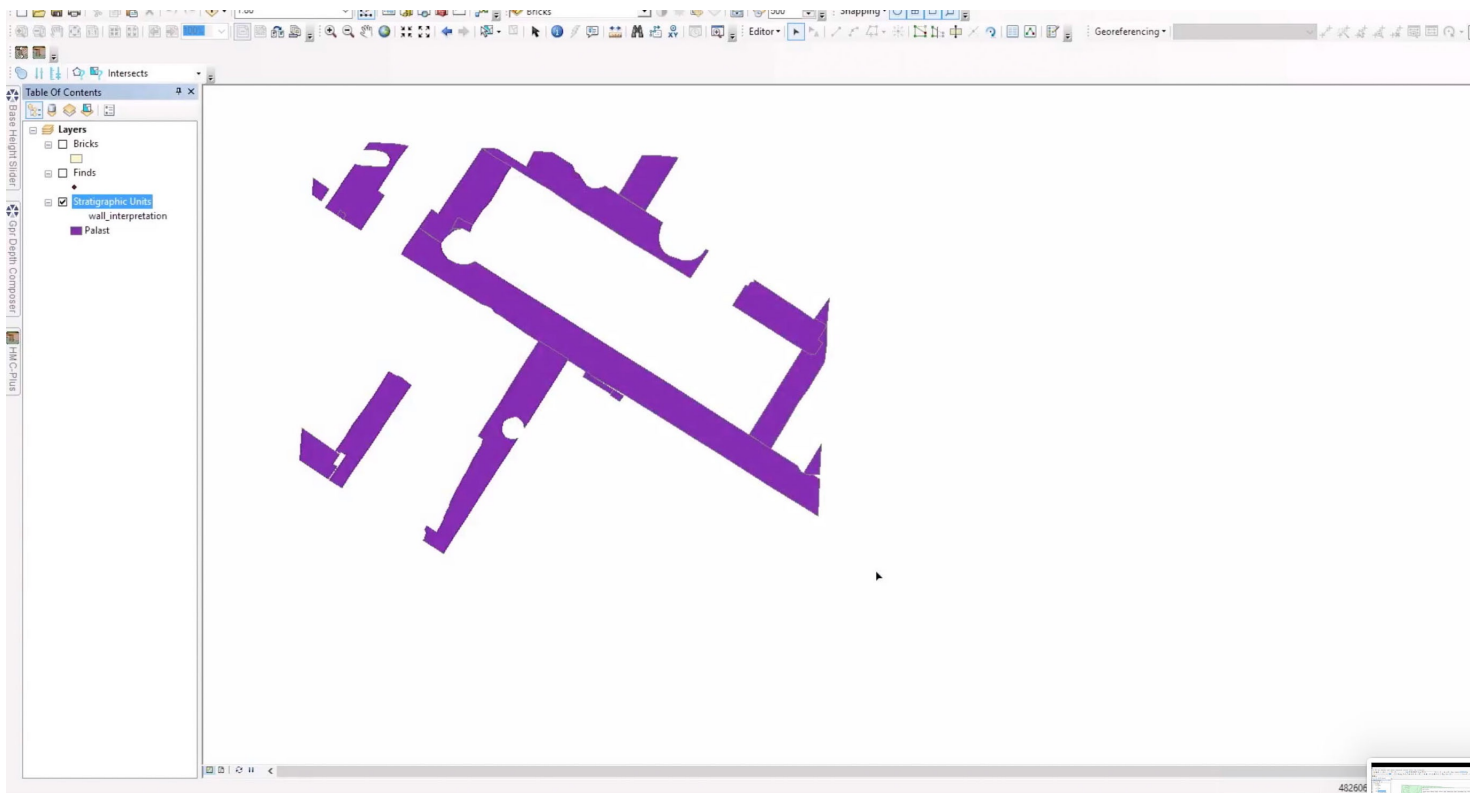
Symbol	Value	Label	Count
	<all other values>	<all other values>	496
	Palast	Palast	17

The dialog box also shows a 'Draw categories using unique values of one field' section with a 'Value Field' set to 'wall_interpretation' and a 'Color Ramp' set to 'Rainbow'. The 'OK' button is highlighted.

<https://youtu.be/rEqhDihwe9U>



TELL EL-DABA ARCHAEOLOGICAL INFORMATION SYSTEM



<https://youtu.be/rEqhDihwe9U>



TELL EL-DABA ARCHAEOLOGICAL INFORMATION SYSTEM

A Puzzle in 4D GIS case study - QGIS

Project Edit View Layer Settings Plugins Vector Bastar Database Web Mesh Processing Help

Layers 3D Kart 1

- Case study area TD F1/J21
 - fire pit
 - pottery
 - small find
 - bone, human remains, human remains?
 - stone
 - wall plaster
 - mud brick
 - brick
 - sand brick
 - sand-mud brick
 - sand brick bench
 - sand brick floor
 - column, foundation, foundation, staircase, floor base
 - fire pit, layer_ash layer_ash_sand, wall_collapse_ash
 - floor
 - foundation_cut
 - layer_wall_collapse
 - layer_mud, threshold_mud
 - layer_sand, wall_collapse_sand
 - layer_sand_mud, wall_collapse_sand_mud
 - oven
 - pit
 - post_hole
 - robber_pit
 - threshold
 - tomb
 - wall
 - Neville pit
 - TD_FZ_1000_TD_F1J21_Planum2

Case study area TD F1/J21: Features Total: 4763, Filtered: 4763, Selected: 4

ORSA_GIS_ID	Excavation_object_ID	Archaeological_object_ID	Archaeological_object_type	Archaeological_object_material	Resources_ID	Phase_ID	Stratum_ID	Excavation_object_type	Find_type	Find_local_number	Find_inventory_number	Base_height	Extrusion	Orientation_classified	Shape_c
1	LBWall_feat_TD_F1J21_...	TD_F1J21_Planum2	wall	sandig	<Null>	TD_E3-2	TD_F1-b2-1					5,9	0,82	WNW-OSO	<Null>
2	LBpit_TD_F1J21_10	TD_F1J21_Planum2		ohne Angabe	TD_FZ_1000			Neville_pit				5,42	0,82	WNW-OSO	recteck
3	LBlayer_TD_F1J21_180	TD_F1J21_Planum1-2	LBlocus_TD_F1J21_L237TD_F1_L10	fire pit	keine	TD_E2	TD_F1_b1					6,02	0,12	keine	rund
4	LBfind_TD_F1J21_960	TD_F1J21_Planum0-1	TD_F1_L2		TD_FZ_1025	TD_E1-02		R-Napf	1		3399	6,12	0,03		
5	LBWall_feat_TD_F1J21_...	TD_F1J21_Planum5	LBWall_TD_F1J21_M71TD_F1_L133	wall	sandig	<Null>	TD_N3-2	TD_F1_e3-2				4,8	0,12	WNW-OSO	<Null>
6	LBWall_feat_TD_F1J21_...	TD_F1J21_Planum5	LBWall_TD_F1J21_M75TD_F1_L213	wall	sandig	<Null>	TD_N3-2	TD_F1_e3-2				4,8	0,28	NNO-SSW	<Null>
7	LBWall_feat_TD_F1J21_...	TD_F1J21_Planum5	LBWall_TD_F1J21_M79TD_F1_LM87	wall	sandig	<Null>	TD_N3-2	TD_F1_e3-2				4,8	0,28	WNW-OSO	<Null>
8	LBWall_feat_TD_F1J21_...	TD_F1J21_Planum5	LBWall_TD_F1J21_M72TD_F1_L216	wall	sandig	<Null>	TD_N3-2	TD_F1_e3-2				4,8	0,17	WNW-OSO	<Null>

Show All Features

Type to locate (Ctrl+K) 4 feature(s) selected on layer Case study area TD F1/J21

Coordinate 3541993.10,365301.21 Scale 1:56 Magnifier 100% Rotation 0,0° Render EPSG:3857

<https://4dpuzzle.oeaw.ac.at/ais/>



INFRASTRUCTURE FOR SPATIAL INFORMATION IN EUROPE (INSPIRE)

is the project for a common spatial data infrastructure in Europe. The European Union wants to use it to support joint environmental policy decisions.



<https://inspire.ec.europa.eu>

<https://www.geoportal.de/DE/GDI-DE/INSPIRE/inspire.html?lang=de>



TIMEMACHINE EUROPE



ABOUT US NEWSROOM LOCAL TIME MACHINES PROJECT SCOUTING SERVICE MEDIA

JOIN US



Amsterdam

Beginning its journey in 2017 and covering the years 1500-2000 AD, the Amsterdam Time Machine pushes the boundaries of science and technology to build a model of this historical city's past.

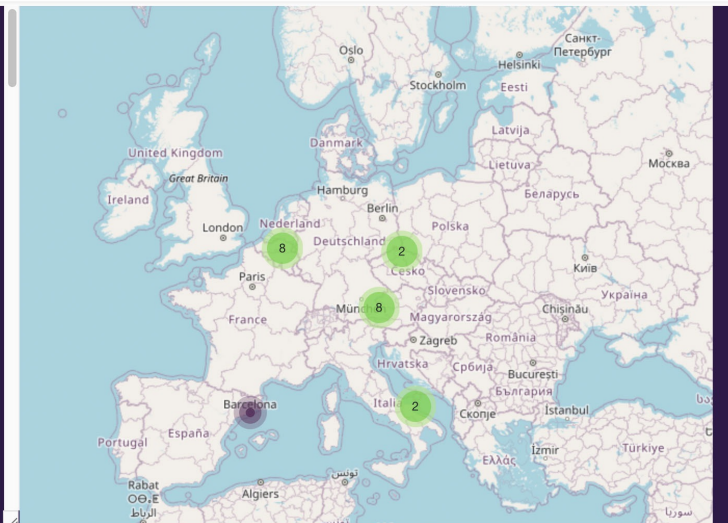
Antwerp

Beginning its journey in 2012 and covering the years 1500-2000 AD, the Antwerp Time Machine pushes the boundaries of science and technology to build a model of this historical city's past.

Barcelona

The Barcelona Time Machine pushes the boundaries of science and technology to build a model of this historical city's past.

Broumov



www.timemachine.eu



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 820323.

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DATING PROBLEMS





DATE FORMATS

B.C.

A.D.

B.C.E.

AD

(before Christian /
common era)

A.D.

(Anno Domini / our
calendar, turn of the
century)

B.C. (before Christ /
the turn of time)

BC

BCE

CE (common era)

av. J.C.

ap. J.C.

aC or AC

dC or DC

The monk Dionysius Exiguus (ca. 470-556 AD) founded a chronological system that takes the year of the Incarnation of the Lord (anni incarnationis Domini) as its starting point.

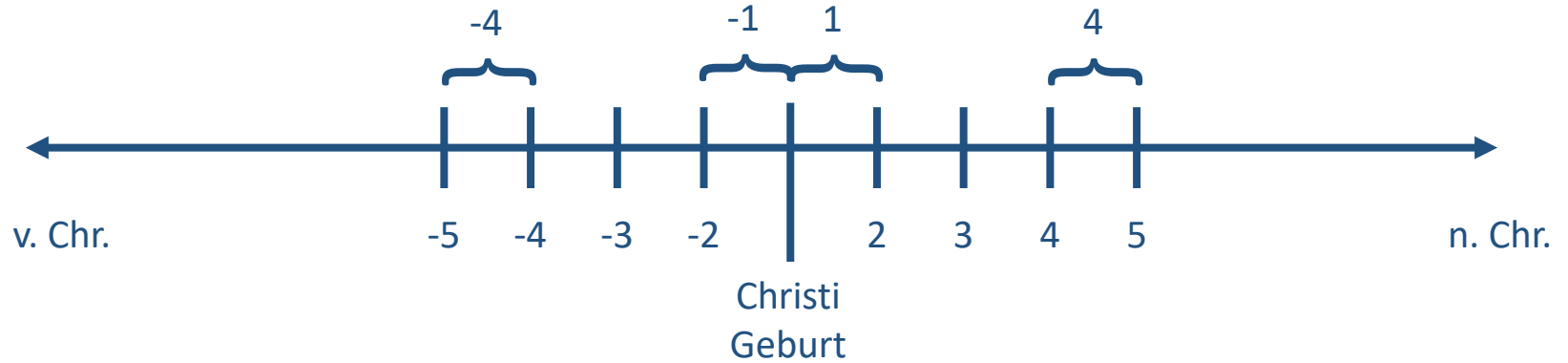
He sets the first year with the birth of Christ on the first day of the year 1 (1.1.1).

There is no year 0!

The system only became established in the Middle Ages. The writings of Beda Venerabilis (d. 735 AD) are important.



DATE FORMATS





OLYMPIADS

Sporting and musical competitions held every four years in Olympia.

The Olympiad is the period of four years.

776 BC = Ol. 1, 1

775 BC = Ol. 1, 2

774 BC = Ol. 1, 3

773 BC = Ol. 1, 4

772 BC = Ol. 2, 1

etc.

SYNCHRONISATION OF THE TIME CALCULATIONS

That the calculation and fixing of the 1st Olympiad in the year 776 is correct can be deduced from other chronological data. The Greek author Diodor 20,5,5 reports of a solar eclipse in the 117th Olympiad in the third year, which can be astronomically calculated with modern methods to 15 August 310 BC. If we now calculate backwards, we arrive at the year 776 with the first Olympiad.



SIGNIFICANCE OF THE OLYMPIAD ACCOUNTS

The Roman author Pliny the Elder, who died during the eruption of Vesuvius in 79 AD, gives the Akmé dates (flowering) of the artists in Olympiads in his Natural History.

Pliny (NH 34, 49-52): Hereupon art ended, but revived in the 156th Olympiad (= 156-153 B.C.) with the artists who, although far below those previously mentioned, were nevertheless esteemed. [...]

Cessavit deinde ars ac rursus olympiade CLVI. revixit, cum fuere longe quidem infra praedictos, probati tamen [...]



COMPETING SYSTEMS

Eponyma count: Naming officials or priests

- Athens: Archons
- Sparta: Ephors
- Rome: consuls, Roman imperial titulatures

Example: The historian Hellanikos of Mytilene based his history on the list of priestesses of the Goddess Hera from Argos.

ab urbe condita = foundation of Rome in 753 BC.

Beginning of Roman tradition in the 3rd century BC: Naevius, Q. Ennius, Fabius Pictor

There is a time gap between the beginning of a historical tradition and the date of the foundation of Rome > Problem of transmission

Historical date is a construction (e.g. M. Terentius Varro 115-27 B.C.)



SOURCE CRITICISM

Sometimes artists pre-date their works,
sometimes dates are falsified



KANDINSKY 1910



ABSOLUTE CHRONOLOGY

Dating by naming the supervising officials (archons).

Archons are officials about whom we have particularly good information for Athens. There, 9 archons originally formed the college of the highest state officials. One could only be elected archon once in a lifetime. The beginning of the establishment of the one-year archontate was given in later sources as 683/2 BC. From the end of the 5th century at the latest, it was customary to name the year after the highest official, the archon eponymos.



Panathenean Prize
Amphora 323/2 BC



Document relief of
405/4 and 403/2 BC.
(Athens, Acr.Mus. 1333)



Select year... AD Choose Calendar

CALENDAR ↓

GO

- CALENDAR ↓
- Attic Calendar
- Chinese Calendar
- Hebrew Calendar
- Hijri Calendar
- Persian Calendar
- Afghan/Pastu Calendar
- Kurdish Calendar
- Ορθόδοξο Ημερολόγιο - Orthodox Calendar
- Catholic Calendar
- Old-Style Orthodox (Russian) Calendar
- Coptic Calendar
- Ethiopian Calendar
- Armenian Calendar
- Baha'i Calendar
- Indian Civil Calendar
- Hindu Traditional
- Japanese Calendar
- Maya Calendar

ANCIENT ATTIC CALENDAR

YEAR: 2020 AD

1st part of the year, Ol.699.3 Embolismic year 1

2nd part of the year, Ol.699.4 Extended year 1



January

Tool for converting ancient calendars into the system used today:

https://www.epistemeacademy.org/calendars/yearly_calendar.html

A. S. Samuel, *Greek and Roman Chronology. Calendars and Years in Classical Antiquity* (München: Beck, 1972)

WEDNESDAY	THURSDAY	FRIDAY	SATURDAY	SUNDAY	MONDAY	TUESDAY
[1/1/2020 O.S:19/12/2019] 7 of Poseideon II, Ol.699.3	[2/1/2020 O.S:20/12/2019] 8 of Poseideon II, Ol.699.3	[3/1/2020 O.S:21/12/2019] 9 of Poseideon II, Ol.699.3	[4/1/2020 O.S:22/12/2019] 10 of Poseideon II, Ol.699.3	[5/1/2020 O.S:23/12/2019] 11 of Poseideon II, Ol.699.3	[6/1/2020 O.S:24/12/2019] 12 of Poseideon II, Ol.699.3	[7/1/2020 O.S:25/12/2019] 13 of Poseideon II, Ol.699.3
WEDNESDAY	THURSDAY	FRIDAY	SATURDAY	SUNDAY	MONDAY	TUESDAY
[8/1/2020 O.S:26/12/2019] 14 of Poseideon II, Ol.699.3	[9/1/2020 O.S:27/12/2019] 15 of Poseideon II, Ol.699.3	[10/1/2020 O.S:28/12/2019] 16 of Poseideon II, Ol.699.3	[11/1/2020 O.S:29/12/2019] 17 of Poseideon II, Ol.699.3	[12/1/2020 O.S:30/12/2019] 18 of Poseideon II, Ol.699.3	[13/1/2020 O.S:31/12/2019] 19 of Poseideon II, Ol.699.3	[14/1/2020 O.S:1/1/2020] 20 of Poseideon II, Ol.699.3



ABSOLUTE CHRONOLOGY

Dating by naming the supervising officials
(archons)

447/46 - 433/32 BC; dating via the naming of the
eponymous archon in the construction accounts
of the Parthenon in Athens.



Inscriptiones Graecae I³ Nr. 436-451: construction accounts of the Parthenon

R. Meiggs - D. Lewis (Hrsg.), *A Selection of Greek Historical Inscriptions* (1989) 162-165 Nr. 59

K. Brodersen u.a. (Hrsg.), *Historische griechische Inschriften in Übersetzung I1* (1992) 67 Nr. 94

B. Wesenberg, *Parthenosgold für den Parthenonbau?*, *AA* 1985, 49-53



ROMAN EMPERORS

The chronological framework for counting the reigning years of the Roman emperors is formed by the *tribunicia potestas* (tribunician power).

Dietmar Kienast, *Römische Kaisertabelle. Grundzüge einer römischen Kaiserchronologie* (Darmstadt: WBG, 1990)

Offices and titles of the Emperor Trajan

cos. I	1. Jan.–30. April 91
cos. II	1. Jan.–Juni 98
cos. II design. III	seit Okt. 98 (?)
cos. III	1. Jan.–28. Febr. (?) 100
cos. III design. IV	seit Okt. 100
cos. IV	1. Jan.–Ende März 101
cos. IV design. V	seit Okt. 102
cos. V	1. Jan.–13. Jan. 103
cos. V design. VI	seit Okt. 111
cos. VI	1.–13. Jan. (?) 112
trib. pot. I	28. Okt. 97–9. Dez. 97
trib. pot. II	10. Dez. 97–9. Dez. 98
trib. pot. III	10. Dez. 98–9. Dez. 99
trib. pot. IV	10. Dez. 99–9. Dez. 100
trib. pot. XXI	10. Dez. 116–7. (?) Aug. 117
imperator II	Herbst 101
imp. III	Frühjahr 102
imp. IV	Herbst (vor 19. Nov.) 102
imp. V	Juli (oder Aug.) 106
imp. VI	Aug. (oder Herbst) 106
imp. VII	Sept. (?) 114
imp. VIII	Okt./Nov. (?) 114 (?)
imp. IX–XI	115
imp. XII–XIII	116 (vor 8. Sept.)
Germanicus	Nov. 97
Dacicus	Herbst 102
Parthicus	20. oder 21. Febr. 116 (FOst)
Optimus	zwischen 10. Aug. und 1. Sept. 114



DATING VIA COIN FINDS

- according to the minting date of the coin
- within the term of the coin



P M TR P COS III P P



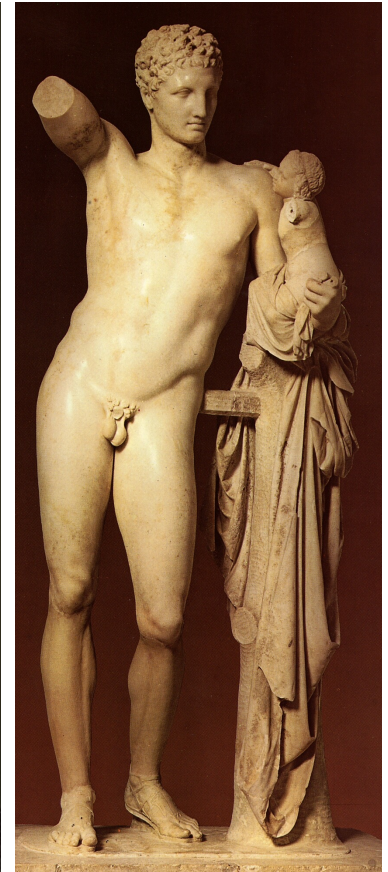
Göttingen AS-01299

https://www.kenom.de/objekt/record_DE-MUS-062622_kenom_127696/2/



RELATIVE CHRONOLOGY

e.g. stylistic development of
Greek sculpture



Critios Boy (c. 480 BC),

Doryphoros of Polycleto (c. 440 BC),

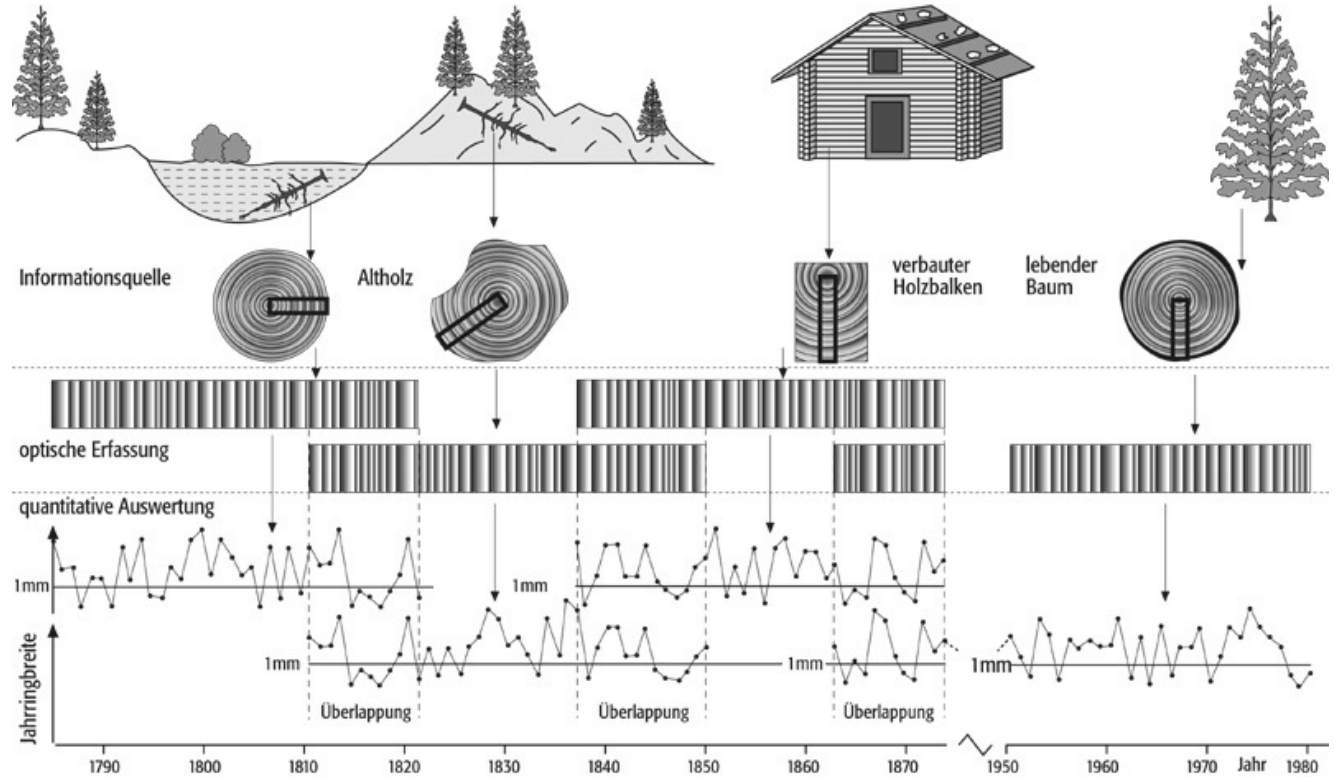
Hermes of Praxiteles (around 340 B.C.)



DENDRO-CHRONOLOGY

According to the felling date of the tree.

In the case of incomplete sequences, not to be dated exactly to the year.



R.E. Taylor and Martin J. Aitken (eds.), *Chronometric Dating in Archaeology* (Springer, 1997)



DENDRO- CHRONOLOGY

according to the felling date
of the tree.

In the case of incomplete
sequences, not to be dated
exactly to the year.

e.g. oldest oak piles of the
Roman bridge of Trier:

18/17 BC 71 AD

144 AD 315 AD





RADIOCARBON METHOD (C14)

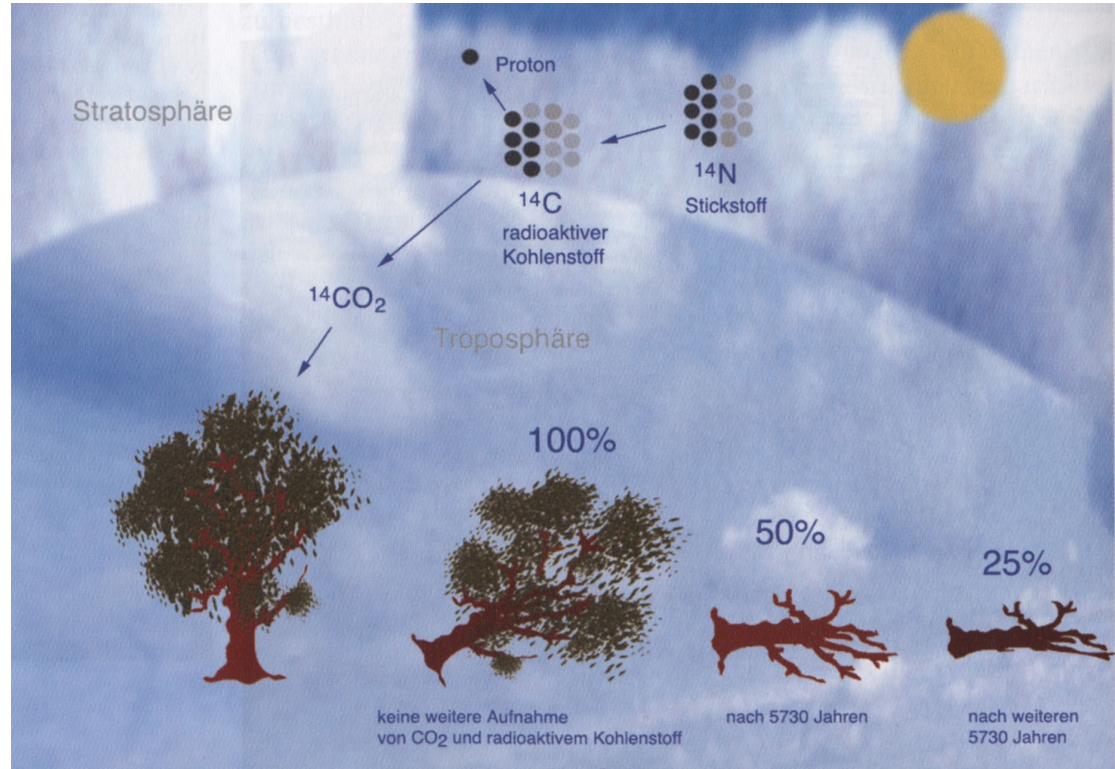
measures the decay of radioactive carbon in organic substances,

relatively imprecise for historical periods, but important for prehistoric archaeology

Conversion of calibrated ^{14}C ages into calendar years continuously from today back to 50,000 years ago.

CalPal is freely available as a download or online version (<http://monrepositum.de/forschung/ausstattung.html#calpal>)

s.a. Oxford Radiocarbon Accelerator Unit (<http://c14.arch.ox.ac.uk/embed.php?File=oxcal.html>)

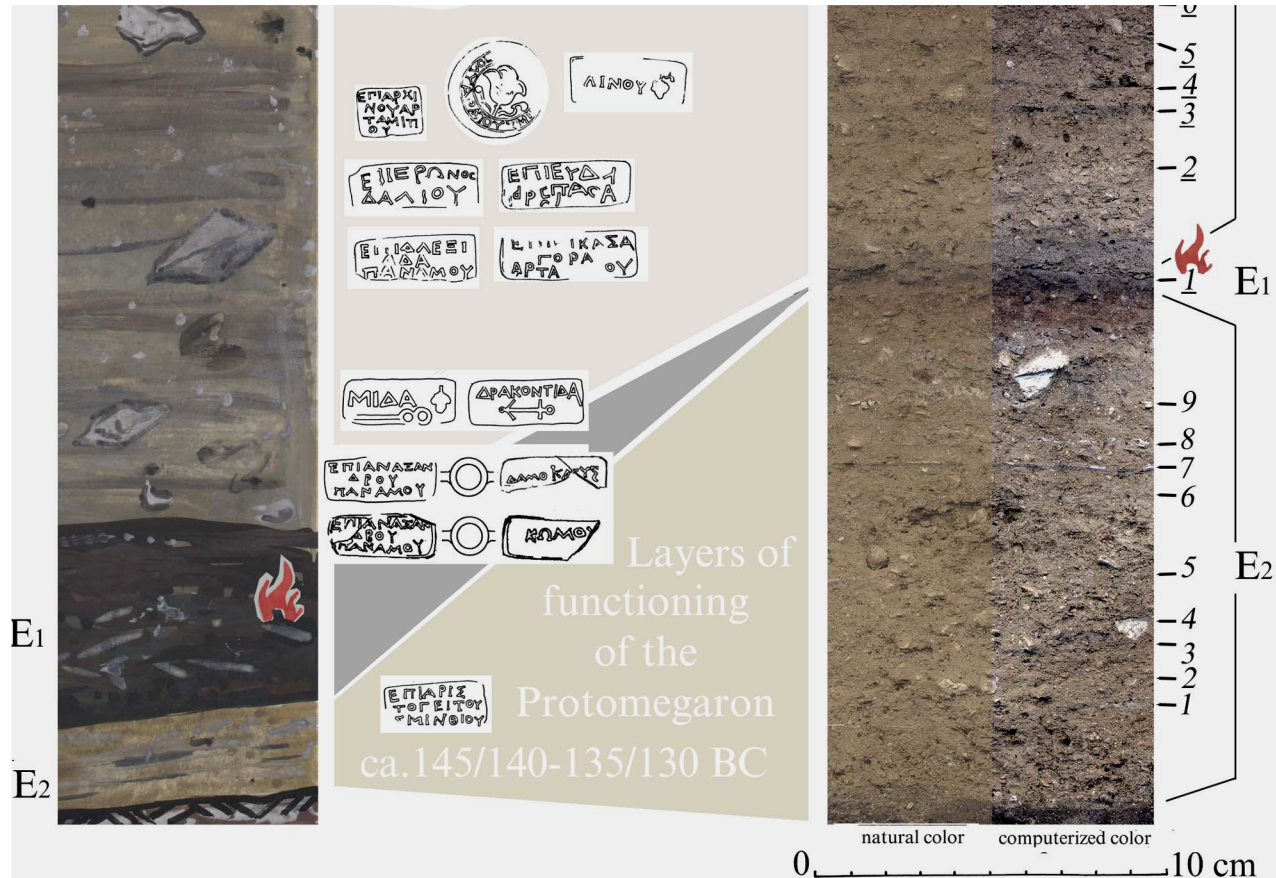




STRATIGRAPHY

Dating of cultural layers via historical events (fire, earthquakes etc.) and finds

Neapolis Synthicae (Crimea, Ukraine), Stratigraphy

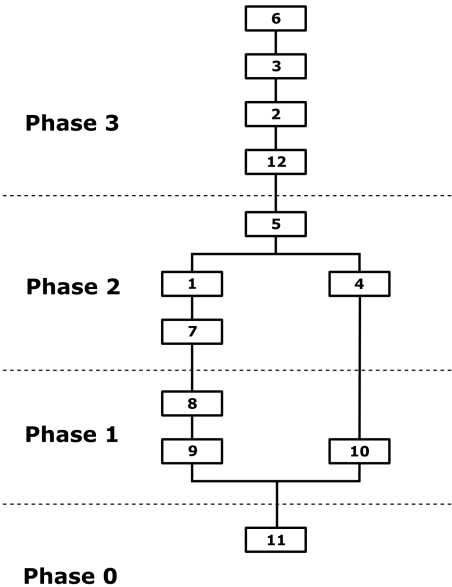
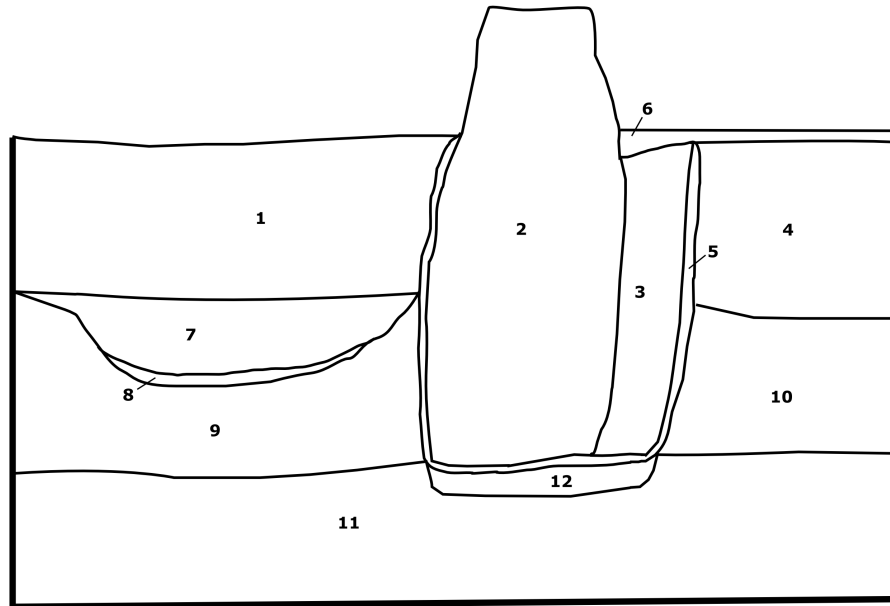


https://antikmuseet.au.dk/fileadmin/www.antikmuseet.au.dk/Pontosfilier/BSS_3/BSS3_13_zaycev.pdf



STRATIGRAPHY: HARRIS-MATRIX

Dating of cultural layers via their relationship to each other





STRATIGRAPHY: UNCERTAINTY

An Archaeological Information System (AIS) must be able to react appropriately to changes in the interpretation of the features!

Ian Hodder, The archaeological process. An introduction. Oxford: Blackwell 1999, 87 Abb. 5.4

Result 1



Stratigraphically, A is later than B.

However, if the finds in B are clearly later than A and there are uncertainties about the stratigraphic relationships, we may decide after the excavation to reinterpret the profile/section as follows:

Result 2



B is later than A.

Alternatively, we could decide that we were mistaken about the finds in B and interpret them as earlier than those in A or as secondary in B.

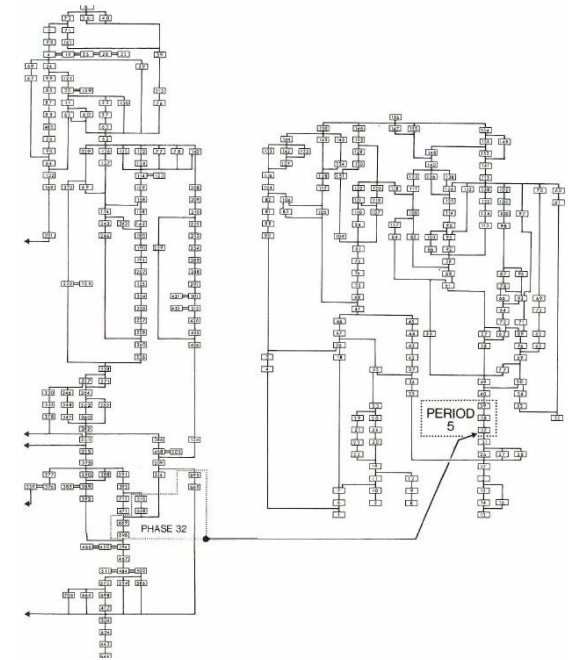
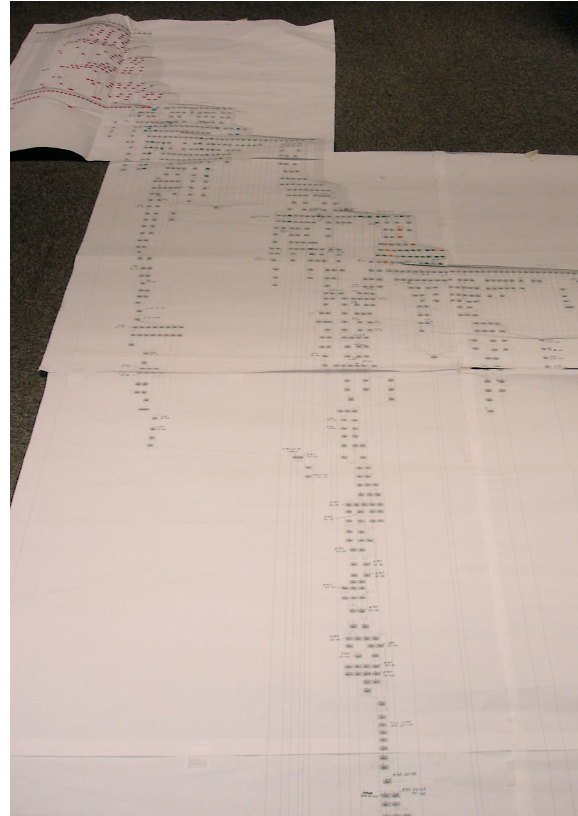
Result 3





STRATIGRAPHY: HARRIS-MATRIX

Dating of cultural layers via their relationship to each other



<http://www.harrismatrix.com/>

<http://www.harrismatrixcomposer.com/>

<https://www.ads.tuwien.ac.at/ArchEd/>



TELL EL-DABA ARCHAEOLOGICAL INFORMATION SYSTEM

The screenshot displays the Tell El-Daba Archaeological Information System (AIS) interface. On the left, a vertical timeline shows the 13th Dynasty (1800 BC) with sub-periods G-4 and d1.2. The central panel is a stratigraphic diagram showing a sequence of deposits: M79, L91, M78, M55, M40, L127, T27, and T112. Deposit M40 is highlighted with a blue box. Below the diagram is a plan view labeled 'Abhub 9 (Horizont str. d.1.2)'. The right panel shows a map view with purple polygonal features representing archaeological units. The 'Properties' panel for 'Deposit M40' lists: ID: M40, Name: M40, Type: Deposit, Date: d/1.2 (1800 BC - 1785 BC), Probability: NaN, and Description: . The 'Table Of Contents' panel lists layers: Bricks, Finds, Stratigraphic Units, wall_interpretation, and Palast. The 'Table' panel at the bottom right contains the following data:

OBJECTID*	SHAPE*	Type	OREA_GIS_Identifier	Excavation object ID	Stratum ID	Stratum_GIS_comment	Phase ID	Phase
145	Polygon	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>
146	Polygon	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>
147	Polygon	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>
148	Polygon	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>
149	Polygon	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>
145	Polygon	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>
146	Polygon	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>
147	Polygon	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>
148	Polygon	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>
149	Polygon	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>

<https://youtu.be/rEqhDihwe9U>



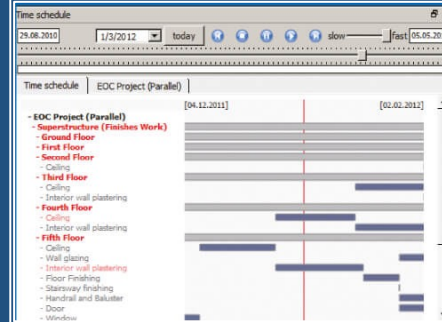
DATE FORMATS

Dating	Example	Data type
BC, AD, BC/AD		Sign (+ / -)
exactly to the day	e.g. 12.05.113 (dedication of Trajan's Column)	DATE
exactly to the year	e.g. 112	INTEGER
to an exact period of time	e.g. 367/66 BC (= {-367; -366} oder {-18.07.367...-07.07.366})	SET, ARRAY
to an approximate period of time	e.g. ca. 20–10 BC, middle Augustan, later 1st cent. BC	(SET, ARRAY)
before or after a period	before 79, the eruption of Vesuvius	(SET, ARRAY)
before or after a period	stratigraphic result	(SET, ARRAY)

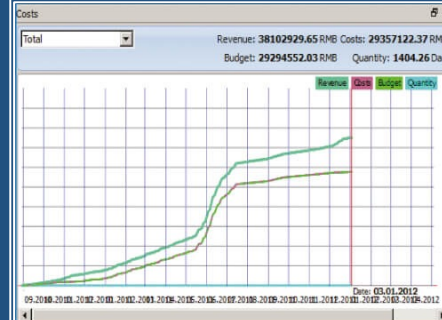


THE DIGITAL MODELLING OF SPACE AND TIME

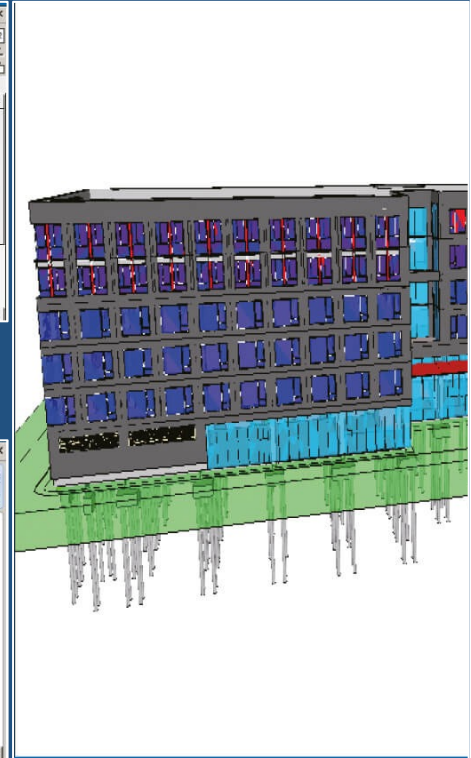
4D Time

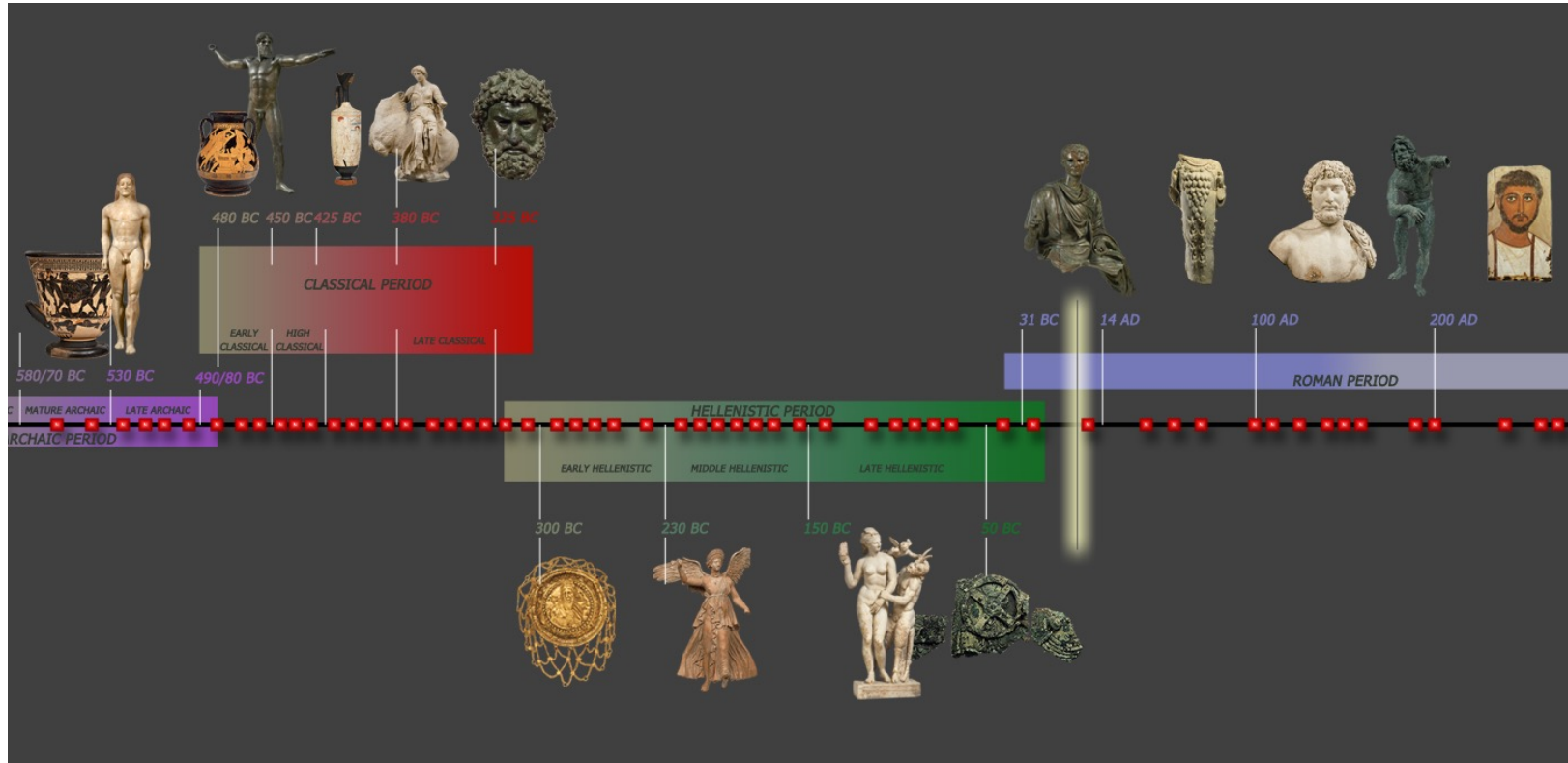


5D Costs



3D Space





Daniel Rosenberg and Anthony Grafton, *Cartographies of Time: A History of the Timeline* (New York: Princeton Architectural Press 2009)

Tiki-Toki Tower of London 3D

ABOUT THIS TIMELINE | CREATE A TIMELINE | LOGIN | FREE SIGN UP

Image courtesy of Matthias Kabel via WikiMedia Commons

Architecture & Works

Events

Reign

1065



1075 - 1100
The White Tower Built

1066
The Tower Founded



1087 - 1100
William II



CLICK TO FIND OUT MORE

1066 - 1087
William I

2d

1084

1187

1238

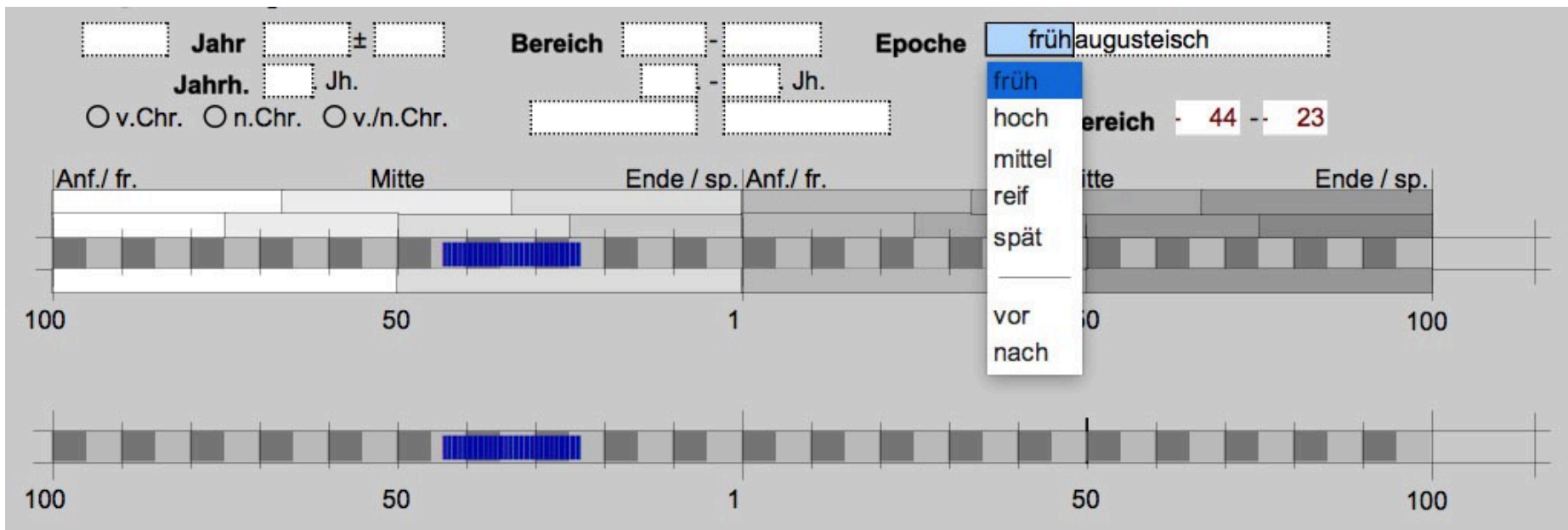
1345

1461

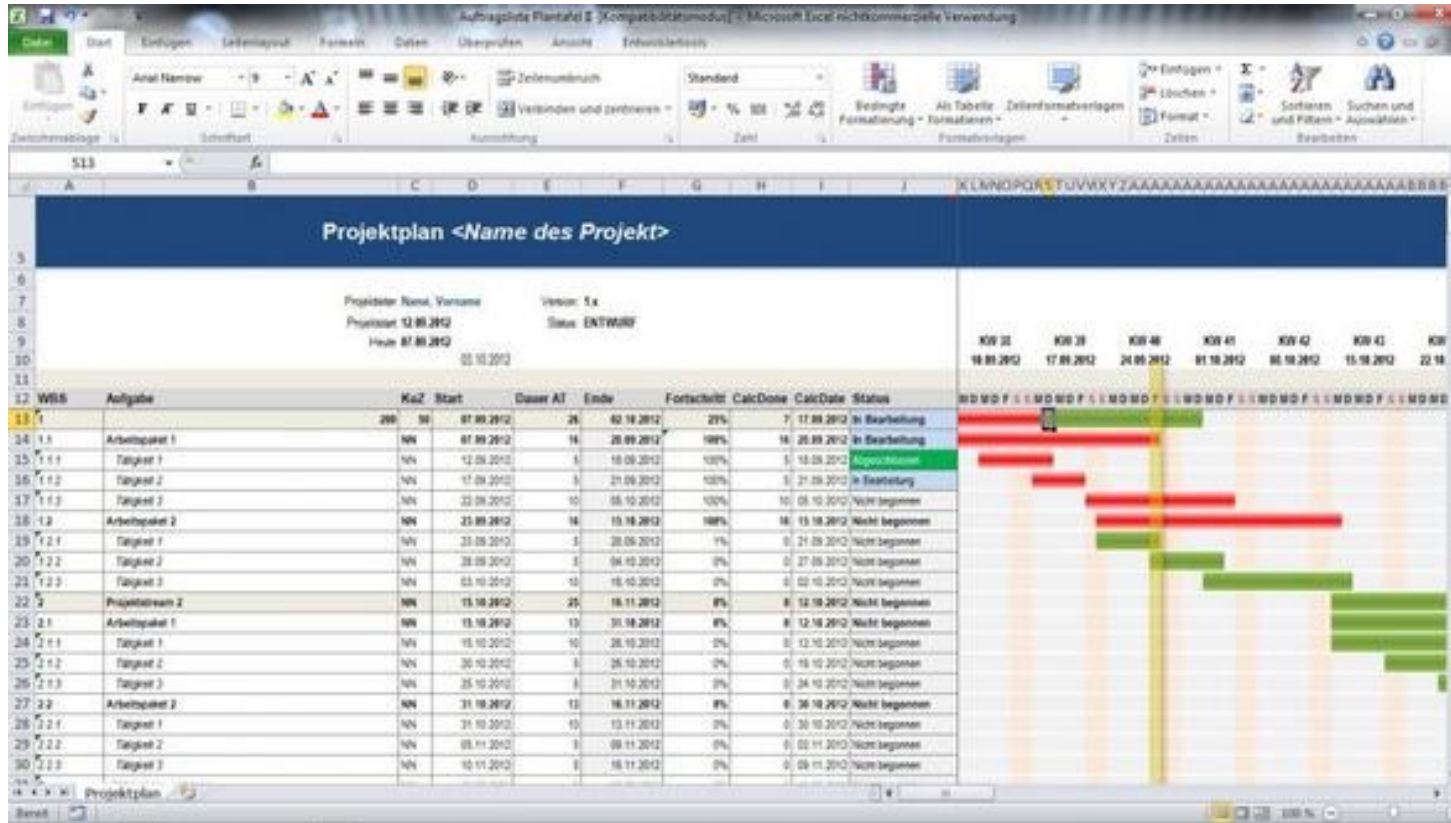
1486

1553

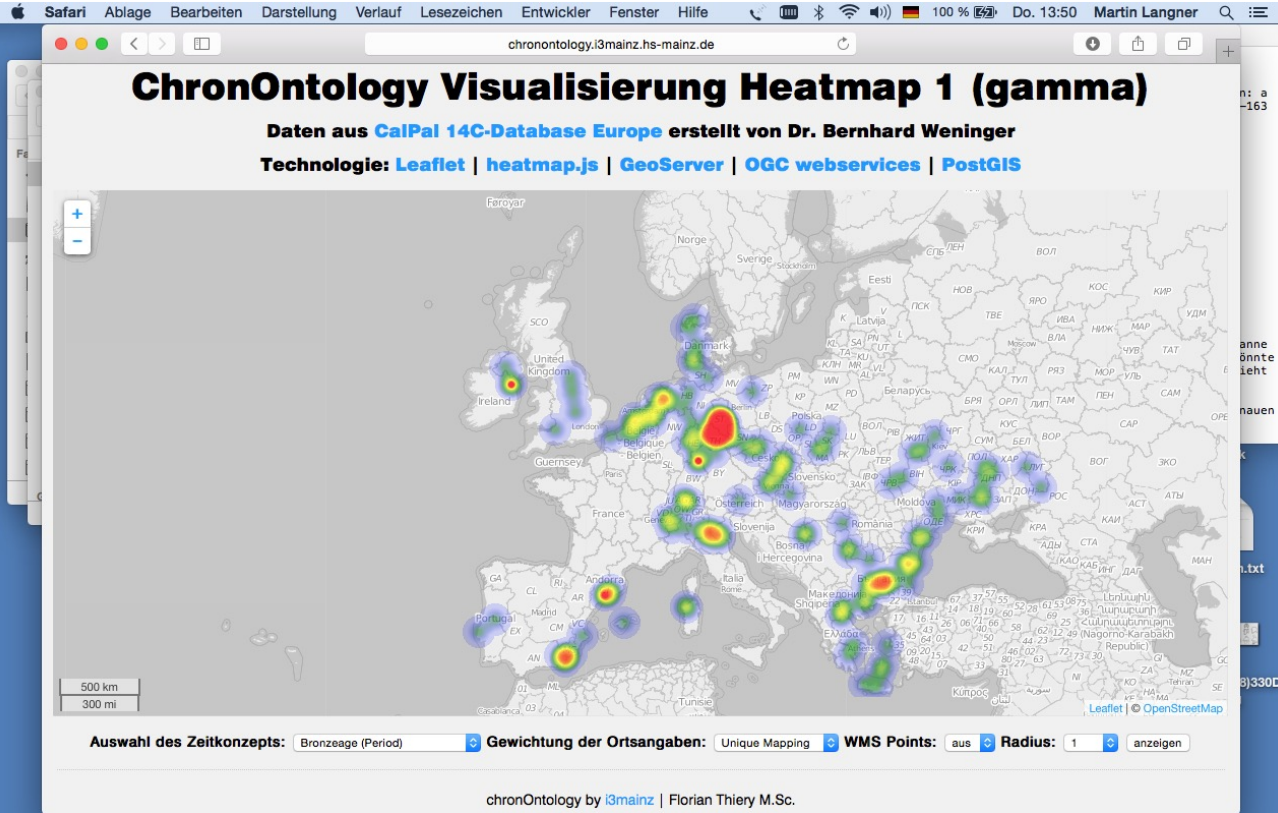
16



- linguistic datelines that contain values as text
- numerical timelines containing numerical values
- interactive, clickable, zoomable



Example: Project planning with Excel





iDAI.chronontology

 Über ChronOntology [FAQ](#) [API](#) [Deutsch](#) [Anmelden](#)

digitale Provenienz

chronOntology 142

Epochentypen

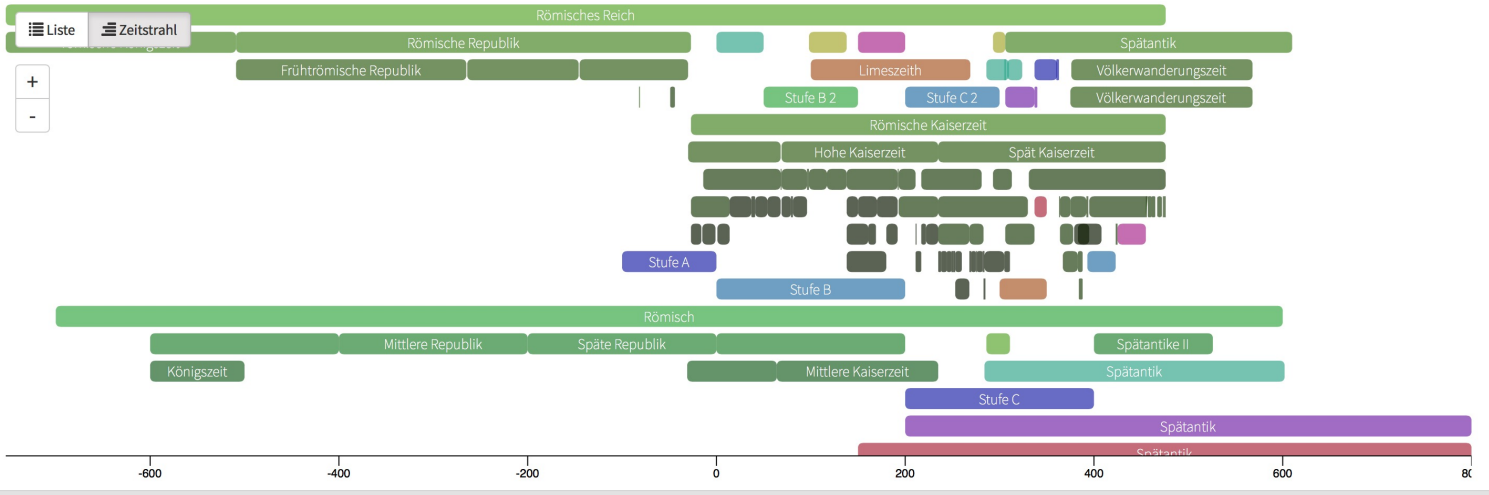
- politisch 113
- materielle Kultur 19
- Architektur 10
- Glasgefäße 9
- chronologische Unterteilung 6

Region

- Weströmisches Reich 25
- Römisches Reich 15
- Europa 13
- Deutschland 9
- Byzantinisches Reich 5

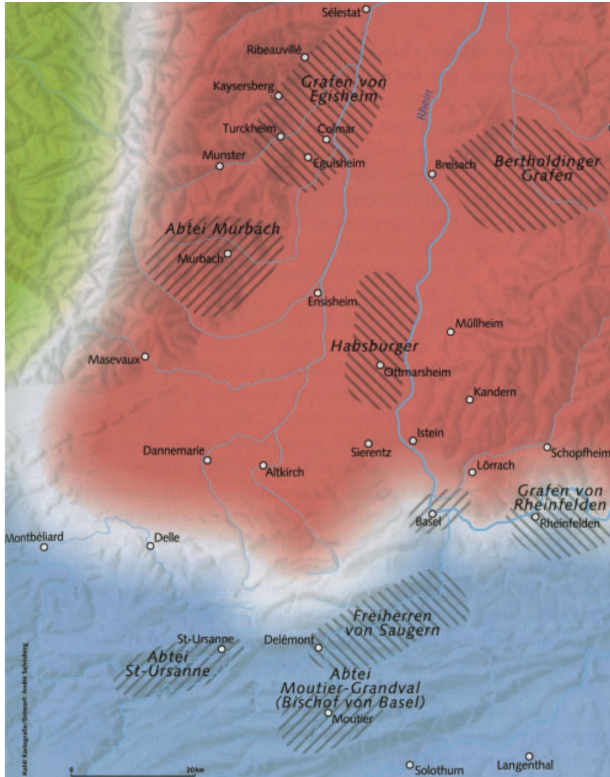
Ist gesetzt

- Zeitliche Ausdehnung
- Ist benannt nach
- Hat Kerngebiet
- Räumlich Teil von

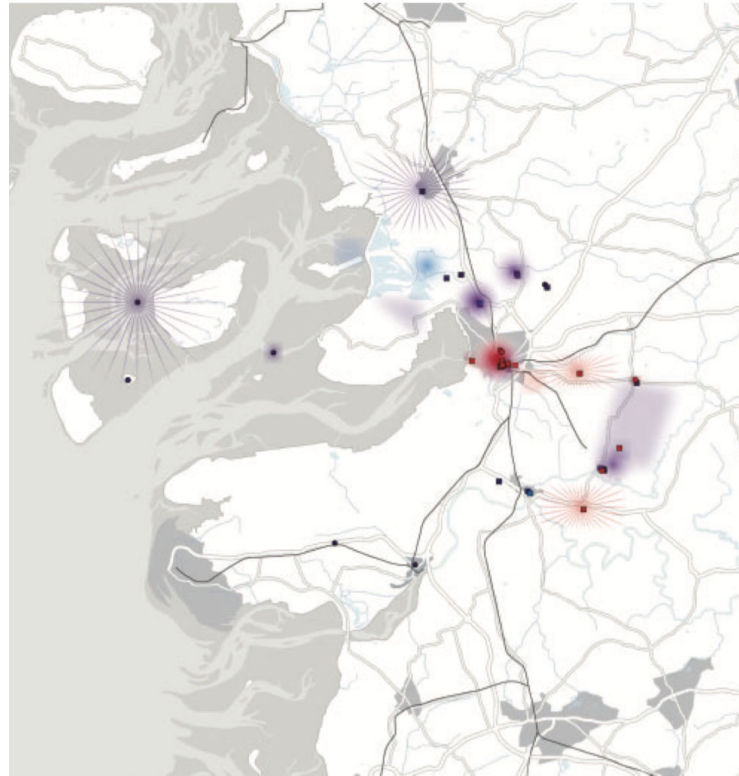




Category	Examples for Space	Examples for Dating
Uncertainty	Hand sketch, undocumented boundaries	"ca. 300", "+/- 10 min."
Lack of precision	"near Rome", abbreviated coordinates	"once a week", „later Imperial Period“
Lack of unambiguity	"Newport“, spelling variance	"ca. 300" ↔ "ca. 305"
Incompleteness	due to light conditions, overgrowth	Gaps in tradition,
Inconsistency	"from Rome"/ "in Rome"	"12h" (12 hours/12 o'clock)
Limited validity	Age of the maps	Different chronology systems
Credibility	Local Knowledge?	Pre- or backdating
Subjectivity	Local ↔ Foreign	Experts ↔ Students
Interrelation	Modified version of a map	Anachronism
Error in acquisition	Multiple input sources	Conversion problems



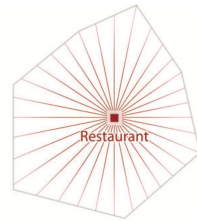
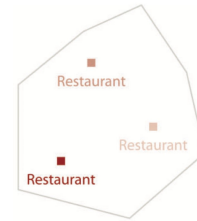
Principalities around 1000 AD, Historischer Atlas der Region Basel. Geschichte der Grenzen (Salvisberg, 2010)



Locations in Theodor Storm's novella "The Rider on the White Horse"

Anne-Kathrin Reuschel and Lorenz Hurni, Mapping Literature: Visualisation of Spatial Uncertainty in Fiction, The Cartographic Journal 48 no. 4 (2011), 293–308:

http://www.literaturatlas.eu/files/2012/02/Reuschel2011_CAJ.pdf





THE VISUAL VARIABLES



location



size



color hue



color value



color saturation



orientation



grain



arrangement



shape

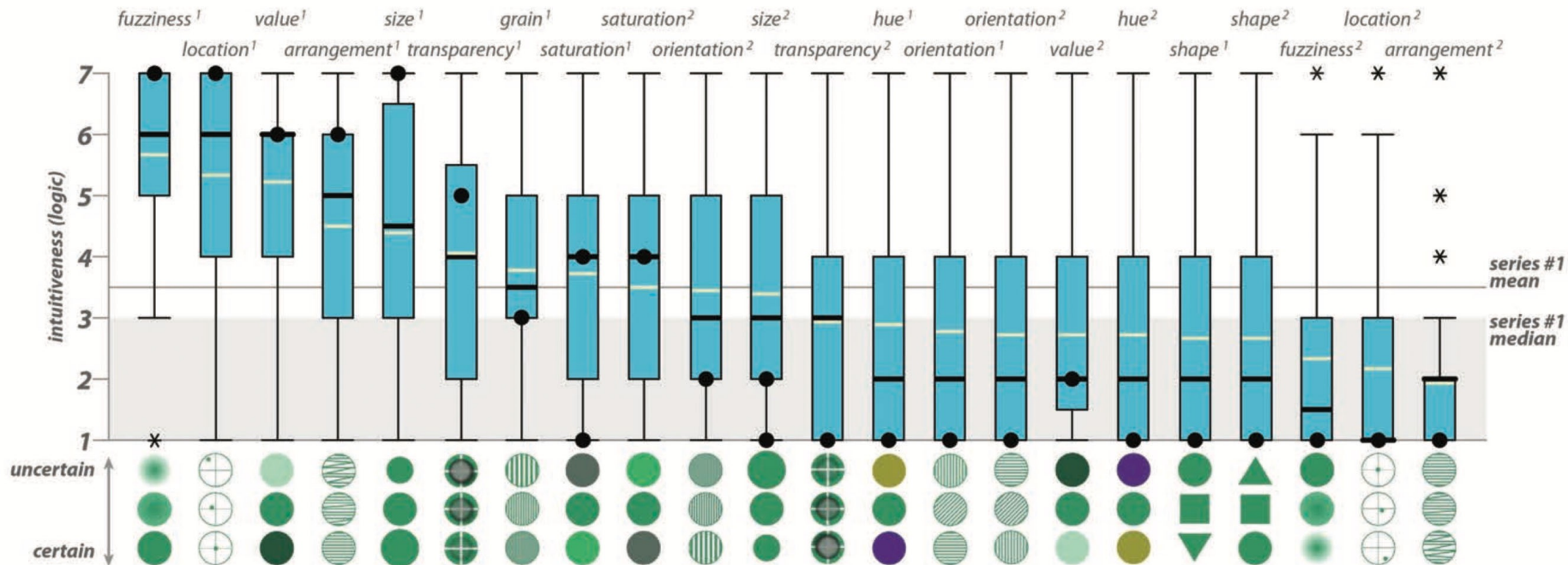


fuzziness

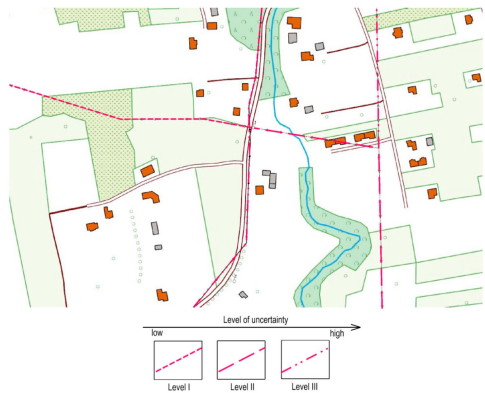
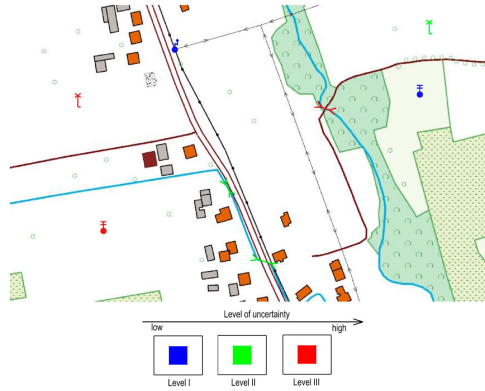


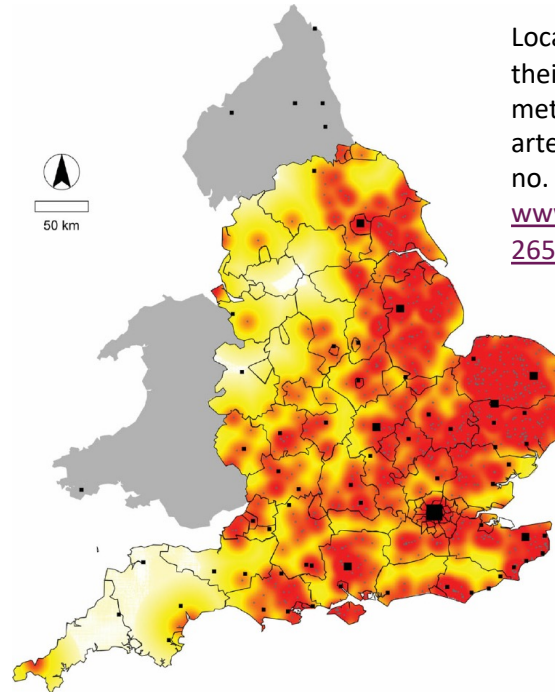
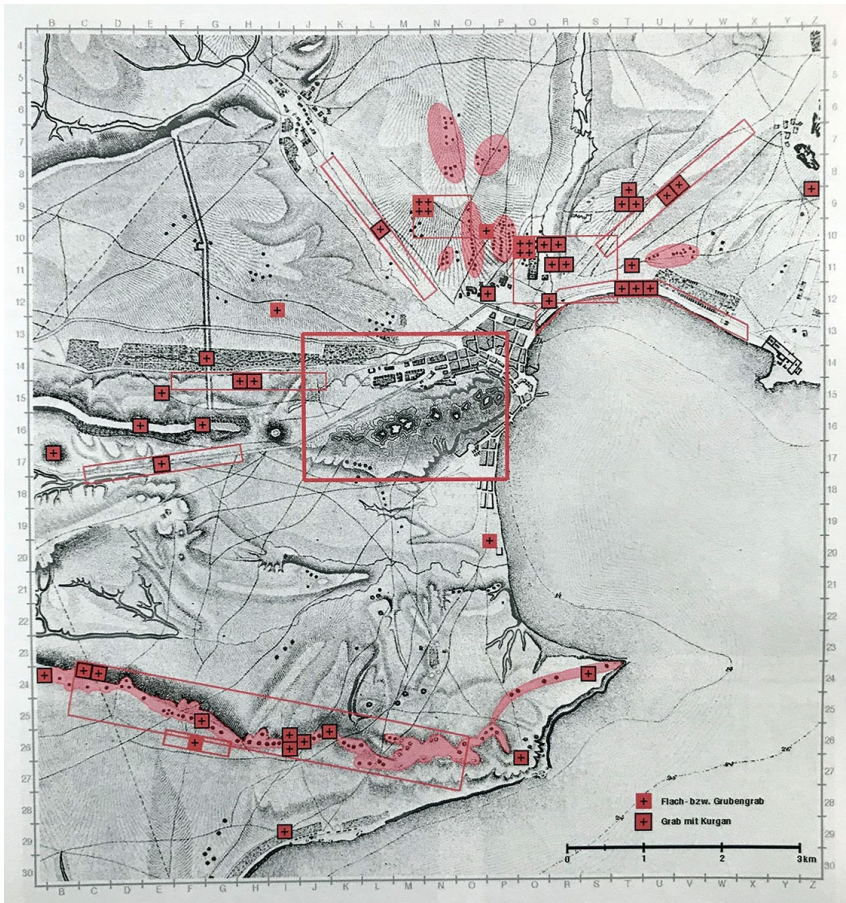
transparency

A. MacEachren et al., "Visual Semiotics & Uncertainty Visualization: An Empirical Study," *IEEE Transactions on Visualization and Computer Graphics* 18, no. 12 (2012), 2496–2505:
www.researchgate.net/publication/260582970



A. MacEachren et al., "Visual Semiotics & Uncertainty Visualization: An Empirical Study," *IEEE Transactions on Visualization and Computer Graphics* 18, no. 12 (2012), 2496–2505: www.researchgate.net/publication/260582970





Locations of Anglo-Saxon coins and their range. Andrew Bevan, Spatial methods for analysing large-scale artefact inventories, *Antiquity* 86 no. 332 (2012), 492–506: www.researchgate.net/publication/265151629

F. Fless – A. Lorenz, Die Nekropolen Pantikapaions im 4. Jh. v. Chr. in: F. Fless – M. Treister (Hrsg.), *Bilder und Objekte als Träger kultureller Identität und interkultureller Kommunikation im Schwarzmeergebiet*, Kolloquium in Zschortau/ Sachsen vom 13.-15. Februar 2003, *ASTK* 6 (2005) 17-26 Taf. 3



https://upload.wikimedia.org/wikipedia/commons/thumb/d/d2/Carlos_V_en_Mühlberg%2C_by_Titian%2C_from_Prado_in_Google_Earth.jpg

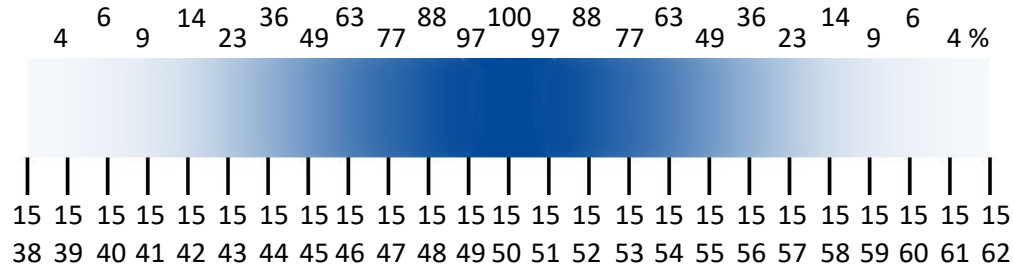


CHRONOLOGICAL UNCERTAINTY

e.g. „Middle of the 16th century“ ≈ „1545–1555“

Middle of the 16th century: Titian paints the painting "Emperor Charles V after the Battle of Mühlberg"

24th April 1547: Charles V defeats the troops of the Schmalkaldic League in the Battle of Mühlberg





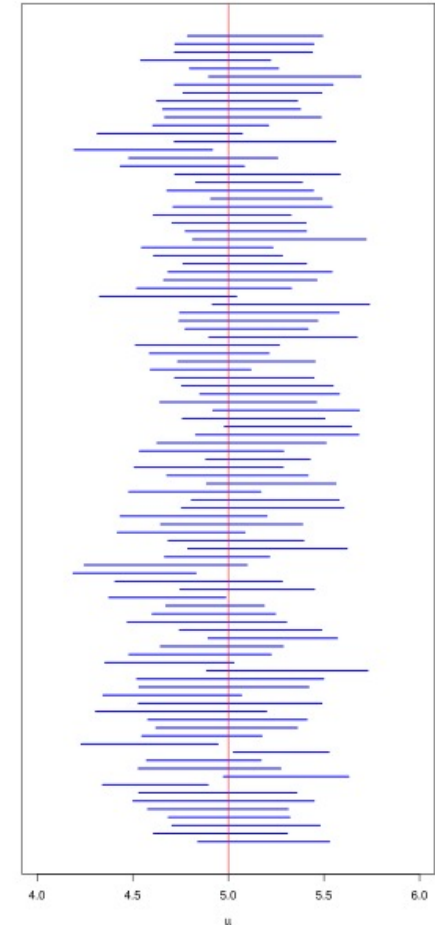
CHRONOLOGICAL UNCERTAINTY

could also be modelled as a confidence interval, i.e. as a range in which the dating information is located with a certain probability.

However, this approach presupposes measurable values, which are usually not available for dating.

Confidence intervals at the 95 % level for 100 samples of size 30 from a normally distributed population. Of these, 94 intervals cover the exact expected value $\mu = 5$; the remaining 6 do not.

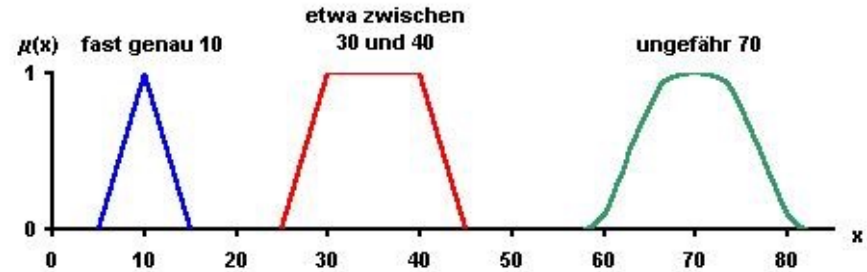
(<http://de.wikipedia.org/wiki/Konfidenzintervall>)



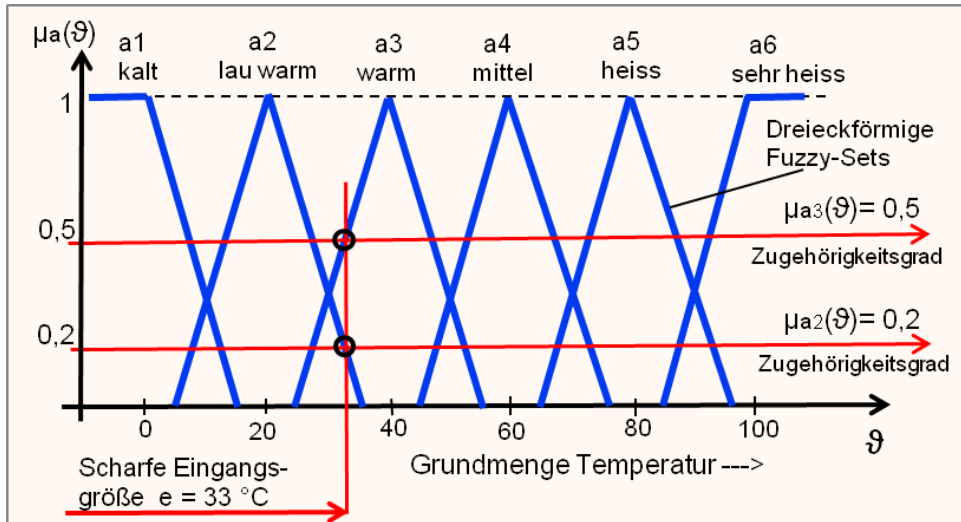


CHRONOLOGICAL UNCERTAINTY

Fuzzy set theory operates with indeterminate conceptual scopes in the sense of referential semantics. This procedure, which is based on the theory of fuzzy sets, could also be applied to humanities data sets and search results by actually visualising the data as fuzzy sets whose density decreases at the edges, whereby linking and overlapping is also possible.



FUZZY SET THEORY

**Subjektive linguistische Begriffe der Temperatur**

- * Darstellung Fuzzy-Variable A der Temperatur mit ihren Termen a1.....a6.
- * Überlappungen der Fuzzy-Sets zwischen 20% bis 50 % sind üblich.
- * Symmetrie der dreieckförmigen Fuzzy-Sets ist nicht zwingend.
- * 2 Fuzzy-Sets a2 und a3 sind wie dargestellt aktiv ("feuern").
- * Fuzzifizierung $e_1 = 33$ °C $\rightarrow \mu_a(\Theta) = \{0; 0,2; 0,5; 0; 0; 0\}$

Representation of a fuzzy basic set A with 6 subsets a1 ... a6

(<http://de.wikipedia.org/wiki/Fuzzy-Regler>)



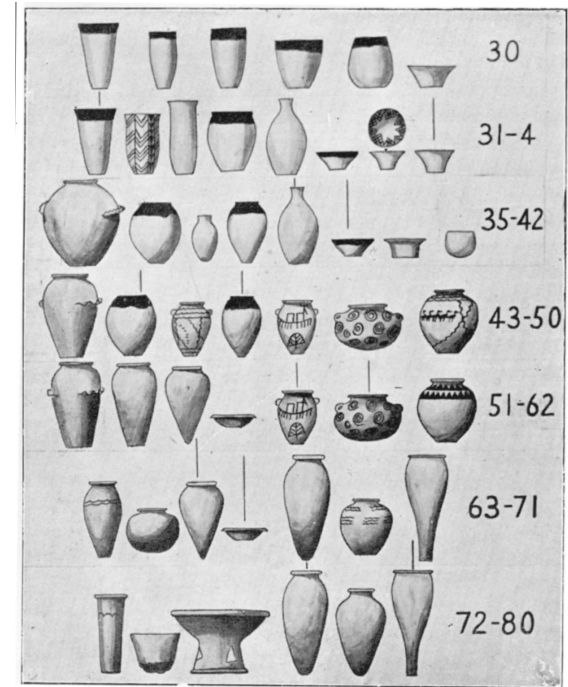
CONTEXTUAL SERIATION

of the named vessel types and graves 1-7:

1 = Context contains the vessel type

0 = Context does not contain the vessel type

	ABCDEFG			ABCDEFG		FEAGDBC	
beaker	0000110	beaker	beaker	**	beaker	**	beaker
blackrim	1000110	blackrim	blackrim	* **	blackrim	***	blackrim
bottle	1000100	bottle	bottle	* *	bottle	**	bottle
handle	0101000	handle	handle	* *	handle	***	handle
spirals	1001001	spirals	spirals	* * *	spirals	**	spirals
flatpot	0111000	flatpot	flatpot	***	flatpot	**	flatpot
pointed	0001001	pointed	pointed	* *	pointed	***	pointed
	ABCDEFG			ABCDEFG		FEAGDBC	

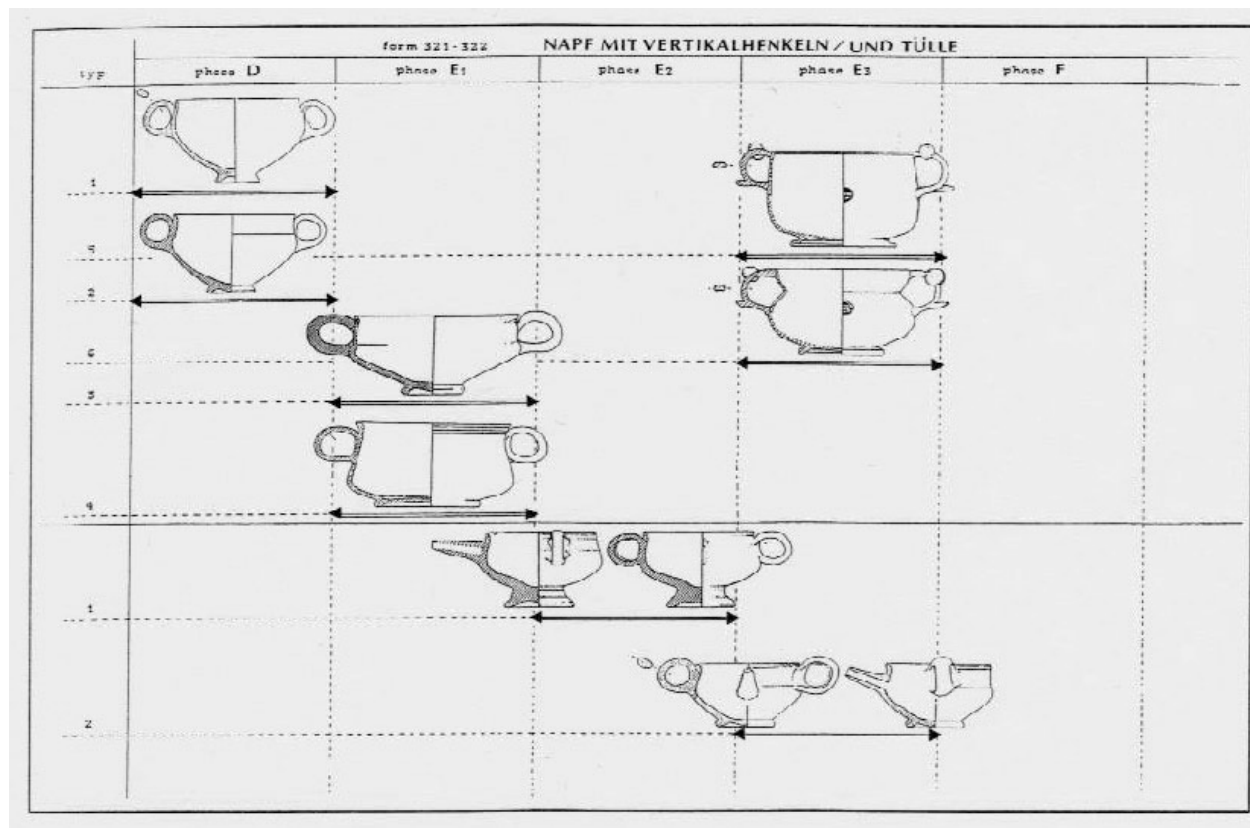


Flinders W. M. Petrie, Sequences in prehistoric remains. *Journal of the Anthropological Institute* 29, 1899, 295–301;
 C. Renfrew – P. Bahn, *Archaeology. Theories, Methods, and Practice* (London 1996) 117; Johannes Müller – Andreas Zimmermann (Hrsg.), *Archäologie und Korrespondenzanalyse. Beispiele, Fragen, Perspektiven* (Rahden/Westf. 1997);
 K. Kris Hirst, *An Introduction to Seriation* (<http://archaeology.about.com/od/dating/ss/seriation.htm>)

SERIATION

of grave goods using
the example of
Taranto

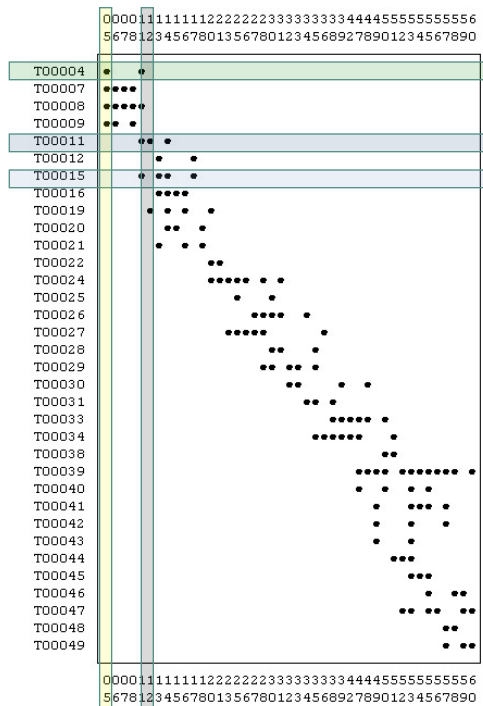
Daniel Graepler,
Relativchronologische Ordnung
hellenistischer Keramik aus der
Nekropole von Tarent mit Hilfe der
Korrespondenzanalyse, in: Δ'
επιστημονικη συναντηση για την
ελληνιστικη κεραμικη, Mytilene
1994, Praktika (Athen 1997) 170
Vgl. auch D. Graepler, Tonfiguren
im Grab (München 1997) 67 f. und
76 f. zum Typenbegriff.



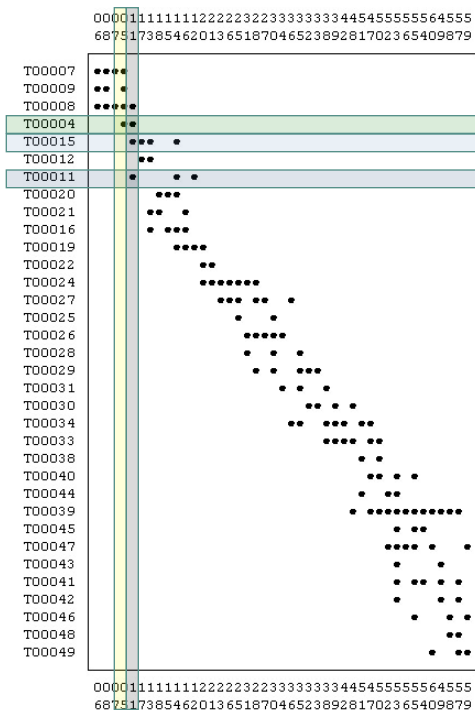


SERIATION

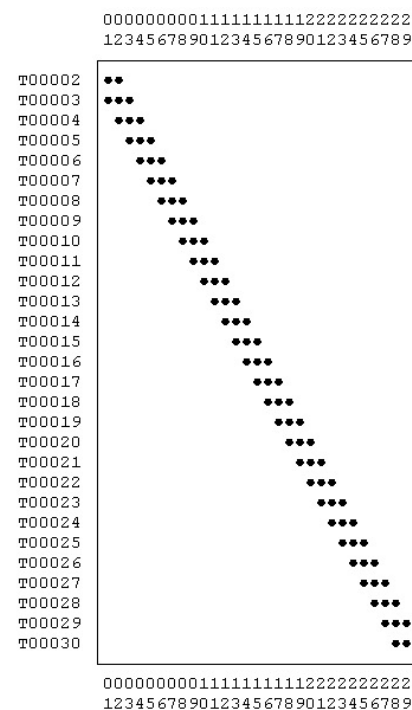
Rearrangement of rows and columns of the table to a diagonal in the table



Rohdaten (unsortiert)



Daten sortiert



Idealtypische Seriation

CHALLENGES

- Modelling of chronological fuzziness with regard to statistical evaluability
- Visualisation and evaluation of uncertainty in geodata
- Increasing the flexibility of acquisition in archaeological information systems
- Retro-digitisation and evaluation of unstructured data



- Definitions and concepts of cultural heritage
- Possibilities of digital geoarchaeology and excavation documentation
- Basics of historical cartography, surveying and geo-referencing and their digital implementation
- Different dating methods and chronology systems and their digital modelling
- GIS / CAD data and their integration, geo-databases, geo-repositories
- Approaches to modelling and visualising uncertainty in spatial and temporal data



- Dealing with time and geodata
- Visualisation of historical situations and archaeological features on maps and in GIS
- Practical experience in the use of GIS and archaeological databases with regard to different usage scenarios



What dating options are available to the historical sciences?

Slide 6. 62–71

Give two examples of digital processing of spatial data.

Slide 26–32

How can dating be expressed linguistically? What difficulties does this pose for digital processing?

Slide 72. 74–80

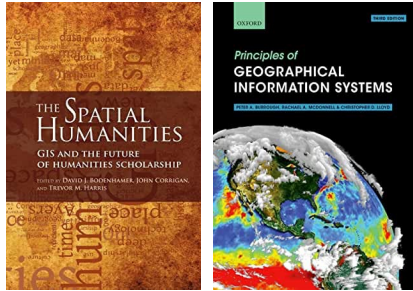
What is meant by the term cultural heritage? What opportunities does digital acquisition offer here?

u.a. Slide 2–3

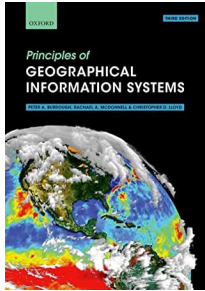
What are the benefits of digital geovisualisation?

Slide 29

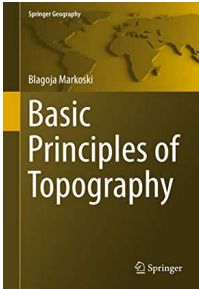
What do you think a historical geo-information system should be able to do?



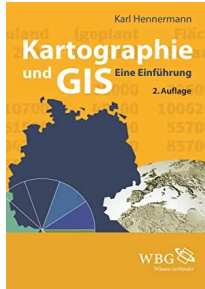
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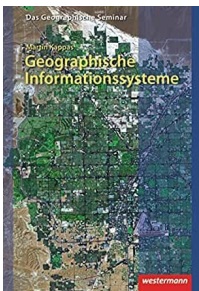


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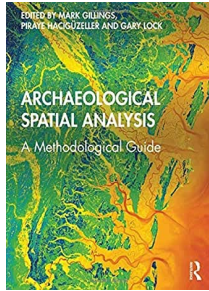
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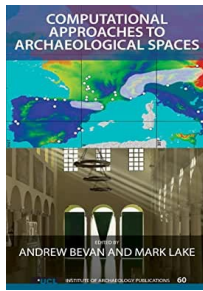
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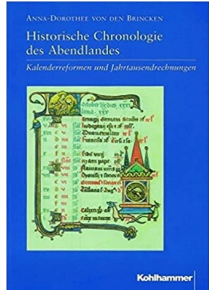
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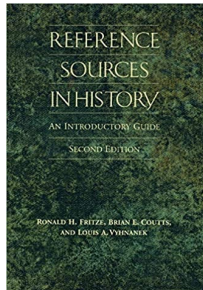
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Folie 64: https://www.spektrum.de/lexika/images/geogr/dend_chr.jpg

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